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# RAILWAY RADIO OPERATED POWER SWITCH MACHINE CONTROL SYSTEM

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TRANSPORTATION DEVELOPMENT CENTRE

by

SIGNALCOM CANADA CORPORATION

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MARCH, 1987

SIGNALCOM CANADA CORPORATION
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Un sommaire en français de ce rapport est inclus avant la table des matières.

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17. Abstract

This report describes a research project to develop a railway radio operated power switch machine control system. The project included the design and construction of the electronic equipment required to remotely control a railway track power switch machine. A MITAP control head in the locomotive was modified to communicate to a wayside MICROLOK, which in turn monitored the track circuits and vitally controlled the power switch machine. The serial communications link was designed to provide a vital link through an existing radio system. Vital software was implemented to allow the train engineer to select the switch position and have the position confirmed within a safe stopping distance from the switch.

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17. Resume

Ce rapport décrit les travaux de recherche sur la télécommande par radio des aiguillages, y compris l'étude et la réalisation du matériel électronique nécessaire à la manoeuvre télécommandée des mécanismes électriques y relatifs. Une unité MITAP embarquée a été adaptée pour qu'elle puisse communiquer avec un composant appelé MICROLOK placé au sol, connecté à quatre circuits de voie et commandant la manoeuvre de l'aiguillage. Une liaison sérielle a été concue en vue de relier les composants du système entre eux, via la liaison hertzienne à fréquences vocales existante. Un logiciel d'application a été réalisé; il permet qu personnel de conduite de manoeuvrer un aiguillage à distance et de recevoir un message qui confirme la position de celui-ci alors que le train est encore à une distance d'arrêt suffisante.

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The authors would also like to thank Union Switch & Signal for the loan of a MICROLOK rack which performs the final vital link in the communications system.

SUMMARY

The Railway Radio Operated Power Switch Machine Control System project developed the communications protocol, software and hardware modifications to implement the remote control by locomotive equipment of a wayside power switch. The object of the system is to improve the efficiency of train movements by eliminating the need for the locomotive to stop for every change in switch position. The safe routing of trains will still be directed by the dispatcher as the locomotive engineer requires the proper operating authority prior to communicating with the radio controlled switch. The radio controlled switch will allow the locomotive engineer to set the track power switch to the desired position and return it to the normal position after the locomotive has traversed the switch. Three new hardware components were developed to enable remote control of power switches: the cab MITAP, the wayside MITAP and the MICROLOK.

The MITAP is a mobile information terminal and processor manufactured by Signalcom Canada Corporation and specifically designed for locomotive applications. It replaces the conventional voice radio control head, and adds two-way 1200 bits per second data communications capability. Interface to the locomotive engineer is by a 40-character alphanumeric display and a 4x4 numeric and function keypad.

The cab and wayside MITAPs are very similar in that they control each end of the RF communications link between the locomotive and and the switch.

Three major functions are performed by MITAP-1200:

1. Voice radio control, including control of synthesized transceivers.
2. Locomotive to wayside data communications over existing voice radio.
3. Data processing and storage.

For data transmissions, the cab MITAP "steals" the radio from the voice channel every 10-15 seconds for a period of approximately 0.5 seconds. The radio is switched to the data channel and data is transmitted and received. The radio is then restored to the voice channel. The MITAP transmits data over the radio at 1200 baud using fast frequency shift keying.

The MITAPs required the design of a "Vital Watchdog Timer" to replace the existing watchdog timer. A new vital watchdog timer board was designed and tested in the MITAP to ensure that, if the MITAP failed, it would be forced to a known inactive state.

The last major component in the control of the switch is the MICROLOK. The wayside MICROLOK is manufactured by Union Switch & Signal. The MICROLOK is responsible for vital control of the power switch and vital interlocking with the track circuits. The MICROLOK has a predefined executive software routine with a user programmable applications program.

If not already provided, four track circuits are required to connect to the MICROLOK. These are the up approach track circuit, over-switch track circuit, the down approach track circuit, and the siding track circuit.

The locomotive engineer initiates the switch control request by entering the switch ID and the requested position into the cab MITAP. At this point, the cab MITAP initiates the communication process with the wayside switch control system (SCS).

In the first stage of the communication protocol, the cab MITAP must establish a communications link with the wayside equipment. If the cab MITAP cannot establish a link with the wayside, then an alarm message is displayed for the engineer to take the appropriate procedures. The possible causes for this could be:

- radio failure (either cab or wayside)
- out of radio range of switch
- error in data message
- switch already in use.

Once the communications link has been established, the cab MITAP enters stage II. In this stage, the switch request is transmitted to the wayside equipment and a response confirming the locking of the switch position is returned. If a problem occurs, the cab MITAP will annunciate the communications error. The possible problems encountered at this stage are:

- loss of communications
- invalid response
- incorrect switch position
- route not clear

In stage III, the cab MITAP monitors the switch position to confirm it stays locked in the correct position. The wayside equipment will keep the switch locked in the same position until the train clears the OS circuit and the locomotive sends a command to return the switch to normal position, or until the locomotive sends a release command and the OS circuit is clear.

Development of the radio switch is progressing in three areas, which are in various planning or implementation stages. These include field trials, interfacing the cab MITAP to a transponder tag system, and transmitting operating authorities

from the dispatch centre directly to the cab MITAP. It is anticipated that the incorporation of these features into the cab MITAP will enable the radio controlled switch to become an integral part of an automatic train control system.

## SOMMAIRE

Cette recherche a porté sur l'adaptation du système de communication à bord des locomotives - protocole de transmission, logiciel et matériel informatique - afin de le rendre apte à la télécommande par radio des aiguillages à manoeuvre électrique. Le but visé est d'accélérer le trafic ferroviaire en éliminant les commandes manuelles qui nécessitent l'arrêt du train avant et après le franchissement d'un aiguillage. Côté sécurité de marche, rien ne changera étant donné que le personnel de conduite doit toujours obtenir l'autorisation du poste de contrôle avant la manoeuvre d'un aiguillage par radio. Par cette manoeuvre, le personnel de conduite met l'aiguillage dans la position voulue et le retourne à sa position antérieure après l'avoir franchi. Le système mis au point par le contractant comprend trois grands sous-systèmes: deux unités MITAP, l'une embarquée et l'autre au sol, et l'unité de manoeuvre MICROLOK.

Le MITAP est un transmetteur-récepteur de données fabriqué par la Signalcom Canada Corporation pour usages exclusivement ferroviaires. Il remplace l'actuelle unité de commande des communications en phonie, en plus d'assurer une capacité bidirectionnelle de transmission de données à raison de 1 200 bits par seconde. Le dialogue homme-machine se fait par une visualisation alphanumérique de 40 caractères et un clavier de 16 touches.

L'unité MITAP au sol ressemble beaucoup à celle qui est embarquée, chacune commandant une extrémité de la liaison hertzienne entre la locomotive et l'aiguillage.

Le matériel MITAP 1200 remplit les trois grandes fonctions suivantes:

1. Commande de la transmission en phonie, y compris des récepteurs synthétisés.

2. Transmission de données entre la locomotive et l'unité au sol, via la liaison hertzienne à fréquences vocales existante.

3. Traitement et stockage de données.

Pour la transmission de données, l'unité embarquée interrompt la transmission en phonie toutes les 10 à 15 secondes pendant une demi-seconde, et utilise ce bref laps de temps pour transmettre et recevoir des données via le circuit approprié, après quoi la transmission en phonie reprend. La transmission de données se fait à la vitesse de 1 200 bauds grâce à la technique de modulation par déplacement de fréquence accéléré.

La mise en service de ce matériel a nécessité le remplacement de la minuterie de surveillance existante par une autre plus moderne qui, en cas de défaillance d'un des deux MITAP, mettra celui-ci dans un état inactif défini d'avance.

Le troisième et dernier sous-système s'appelle MICROLOK. Il est fabriqué par Union Switch & Signal. Placé au sol, il commande la manoeuvre de l'aiguillage et son verrouillage sur les circuits de voie. Il est piloté par un programme "superviseur" et un logiciel d'application programmable par l'utilisateur.

Le MICROLOK est nécessairement connecté aux quatre circuits de voie suivants: le circuit à l'amont et celui à l'aval de l'aiguillage, le circuit d'aiguillage proprement dit et le circuit de la voie d'évitement.

Le personnel de conduite lance la demande de manoeuvre de l'aiguillage en entrant dans l'unité MITAP embarquée le code de celui-ci et la position qu'il doit occuper. Commence alors le protocole de transmission entre l'unité embarquée et l'unité au sol.

Tout d'abord, l'unité embarquée entre en communication avec l'unité au sol. Si la communication ne s'établit pas, un message est affiché attirant l'attention du personnel de conduite. Les causes possibles sont au nombre de quatre:

- défaillance de la liaison hertzienne (côté locomotive ou côté sol),
- aiguillage hors de portée radio,
- erreur dans le message transmis,
- aiguillage déjà occupé.

Une fois la communication établie, la deuxième étape du protocole s'engage: la demande de manoeuvre parvient à l'unité au sol qui répond par un message confirmant le verrouillage de l'aiguillage visé. S'il y a empêchement, celui-ci sera affiché par l'unité embarquée. Il peut être attribué à l'une des causes suivantes:

- perte de communication,
- réponse invalide,
- position d'aiguillage erronée,
- voie encombrée.

Durant la troisième étape du protocole, l'unité embarquée surveille l'aiguillage en permanence pour s'assurer qu'il est bien verrouillé en place. L'unité au sol maintient l'aiguillage en position jusqu'à ce que le train franchisse le circuit d'aiguillage et que l'unité embarquée lance une instruction de retour à la position antérieure ou une instruction de déblocage.

La mise au point du système avance sur trois fronts qui sont soit au stade de l'étude, soit au stade de la mise en oeuvre ou encore à un stade intermédiaire. Ceci comprend les essais en service, l'interfaçage entre l'unité embarquée et un transpondeur de voie ainsi que la transmission des autorisations de marche directement depuis le poste de contrôle à l'unité embarquée. Une fois la mise au point achevée, la télécommande des aiguillages pourra faire partie intégrante de toute automatisation de la marche des trains.

TABLE OF CONTENTS


| | | Page No. |
|---|---|---|
| 1.0 | Introduction | 1 |
| 1.1 | Radio Switch Overview | 1 |
| 1.2 | Radio Switch Operation | 2 |
| 1.3 | Operation with Unequipped Trains | 4 |
| 1.4 | System Safety Parameters | 4 |
| 2.0 | Hardware Description | 5 |
| 2.1 | Locomotive Equipment | 5 |
| 2.1.1 | Cab MITAP | 5 |
| 2.1.2 | Cab Radio | 6 |
| 2.2 | Wayside Equipment | 6 |
| 2.2.1 | Wayside MITAP | 6 |
| 2.2.2 | Wayside Radio | 6 |
| 2.2.3 | MICROLOK Description | 6 |
| 2.2.4 | Local Display Panel | 7 |
| 2.2.5 | Power Switch | 7 |
| 2.2.6 | Test Panel | 7 |
| 2.2.7 | Wayside Battery Connections | 8 |
| 2.3 | MICROLOK | 8 |
| 2.3.1 | MICROLOK Overview | 8 |
| 2.3.2 | CPU Cardfile PCB's | 9 |
| 2.3.3 | I/O Cardfile PCB's | 10 |
| 2.4 | Vital Watchdog Timer | 13 |
| 3.0 | Software Description | 14 |
| 3.1 | Software Overview | 14 |
| 3.1.1 | Cab MITAP Software Overview | 14 |
| 3.1.2 | Wayside MITAP Software Overview | 14 |
| 3.1.3 | MICROLOK Software Overview | 15 |
| 3.2 | Communications Protocol and Packet Format | 15 |
| 3.2.1 | Communications Content | 15 |
| 3.2.2 | Communications Stages | 16 |
| 3.2.3 | Command and Message Sequencing | 18 |
| 3.2.4 | Cab MITAP to Wayside MITAP | 20 |
| 3.2.5 | Wayside MITAP to MICROLOK | 26 |

Table of Contents
continued


| | | Page No. |
|---|---|---|
| 3.3 | Cab MITAP | 28 |
| | 3.3.1 Description of Cab MITAP | 28 |
| | 3.3.2 Major Code Groupings | 29 |
| 3.4 | Wayside MITAP | 30 |
| | 3.4.1 Description of Wayside MITAP | 30 |
| | 3.4.2 Wayside MITAP Human Interface | 31 |
| 3.5 | MICROLOK Application Program | 31 |
| | 3.5.1 Incoming Message from MITAP | 31 |
| | 3.5.2 Outgoing Message to MITAP | 33 |
| | 3.5.3 Program Logic | 34 |
| 3.6 | Existing MITAP Software | 38 |
| 4.0 | Failsafe Operation | 39 |
| 4.1 | MICROLOK Failsafe Features | 39 |
| 4.2 | MITAP Failsafe Features | 40 |
| 5.0 | In House Testing | 42 |


LIST OF FIGURES


| | | |
|---|---|---|
| Figure #1 | MBS Territory Radio Operated Power Switch Control System Block Diagram | 45 |
| Figure #2 | Radio Operated Power Switch Control System Overview | 46 |
| Figure #3 | MITAP 1200 Control Head - Connector Wiring | 47 |
| Figure #4 | Radio Switch - Wayside Rack | 48 |
| Figure #5 | MICROLOK/MITAP Vital Series Link | 49 |
| Figure #6 | Wayside MITAP 1200 - Connector Wiring | 50 |
| Figure #7 | Local Display Panel | 51 |
| Figure #8 | Test Panel Layout | 51 |
| Figure #9 | Test Panel Wiring Diagram | 52 |
| Figure #10 | Vital Watchdog Time Dwg #T209B-B | 53 |

Table of Contents
continued

APPENDIX I: Cab MITAP GENERIC Displays

APPENDIX II: CP Rail Radio Switch Control
Test Installation Drawings
Red Deer, Alberta

## DEFINITIONS

1. Manual Block System (MBS)

   A method of operating trains by the issuance of clearances from a central dispatcher, which permits only one train between two identifiable points. Currently, the dispatcher issues clearances to the train crew by voice radio. The term MBS does not preclude future issuance of clearances by other means, such as data radio. MBS does not provide for enforcement of clearances by wayside or locomotive equipment, and does not provide control of switch machines.

2. Switch Control System (SCS)

   The control system located adjacent to the power switch machine which performs the following functions:

   - Powering and control of the switch machine.
   - Control of a wayside indicator light.
   - Train detection in the switch area, and each approach track on the main route.
   - Vital logic for switch locking and prevention of improper operation.
   - Vital indication to the locomotive via the data radio of: switch position, locking and track circuit occupancy.

   In general, the switch control system consists of a single wired rack of equipment. A block diagram of the system is provided in Figure 1.

3. Mobile Information Terminal and Processor (MITAP)

   The MITAP is the locomotive equipment used as the man/machine interface. The MITAP establishs radio data communications with the switch control system, using the existing locomotive voice radio transceiver. MITAP contains a 2 line, 20 alphanumeric character per line display, and a 4 x 4 keypad.

## 1.0 INTRODUCTION

The purpose of the Railway Radio Operated Power Switch Machine Control System project was for Signalcom Canada Corporation to develop a method whereby the locomotive can remotely select the train routine by radio control of the track power switch. The radio switch would be used in Manual Block System (MBS) territory where no track control system exists.

Currently in MBS territory the locomotive engineer receives operating authority from the MBS dispatcher via the VHF voice radio system. When the track switch position must be changed, the locomotive engineer must stop the train prior to the switch; change the switch position; restart the train and move it through the switch; stop the train again and return the switch to the normal position. This procedure is very costly in terms of the energy required to stop and start the train as well as the time involved.

The radio controlled power switch will enable the locomotive engineer to set the switch to the desired position and return it to the normal position after the locomotive has traversed the switch. There are four major components required for the operation of the radio switch system. These are the cab MITAP, the wayside MITAP, the MICROLOK and the power switch (see Figure #1). The cab MITAP is the locomotive equipment and is interfaced to the radio for communication to the wayside equipment. The MICROLOK is the brain of the wayside switch control system (SCS) in that it controls the power switch machine. The wayside MITAP is similar to the cab MITAP in that it is connected to a radio so that it can communicate with the cab MITAP. It is also connected to the MICROLOK to complete the link between the cab MITAP and the wayside MICROLOK.

The object of the radio controlled switch is to improve the efficiency of train routing in MBS (or CMBS) territory by eliminating the need for trains to make several stops for a track switch position change. The safe routing of trains must still be directed by the control centre dispatcher as the radio controlled switch will not replace this activity.

### 1.1 Radio Switch Overview

In normal operation of the radio switch, the locomotive engineer will initiate a switch control request based upon the operating authority as given the MBS dispatcher. The request is initiated by a keypad entry

on the MITAP, consisting of a switch location number (5 digits), followed by a menu selection of potential actions. For a siding with a single switch under radio control, the options are: normal/reverse, or status report. For a siding, with both ends under Radio Switch Control, the options are: normal/reverse and through/hold. The system can store the upcoming switch ID from the last switch contacted to reduce the number of keystrokes. The switch control request is to be entered after passing the last switch, and prior to a set milepost marker (see Figure # 2). The engineer must receive a reply from the SCS confirming the desired switch position and its locking prior to a second milepost marker which is located at a distance which would allow the train to stop before reaching the switch.

The lack of confirmation of the proper switch status prior to the second marker will require, by operating rules, a slowing of the train to a restrictive speed, with preparation to stop prior to the switch. Under this condition, when the train has reached an approach track circuit, action will be governed by a visual switch position indicator. If the indicator denotes proper position and locking, the engineer can proceed with full speed authorization. Otherwise, the train must be stopped prior to the switch for a visual inspection and hand operation, if required.

In the event the initial switch inquiry results in a message from the SCS indicating another train has requested the switch control, or if a conflicting track circuit is occupied (OS or approach), the engineer will be instructed to immediately initiate a braking action and notify the MBS dispatcher of the discrepancy.

In situations where two switches to be controlled are in overlapping radio range, such as both ends of a siding, locking of the first switch will be confirmed first, followed by separate confirmation for the second switch. The ID of the second switch in the siding is obtained from the first switch.

## 1.2 Radio Switch Operation

The system is designed to use existing VHF frequency voice equipment and frequency allocations with data and voice operations shared. The system can also utilize a separate data radio, where available.

All data exchanges are initiated by the locomotive, using a data channel separate from the voice channel, which is automatically selected based upon the switch ID being requested. The cab MITAP will switch the radio from voice to data for an exchange, and then back to voice. Voice radio use initiated by the locomotive engineer will take priority over the data communications. Interruptions to voice traffic coming to the locomotive will be less than 0.5 seconds in duration.

Upon initiation by the locomotive engineer, the MITAP will periodically switch to the data channel, transmit a data message, wait a set time for a reply, and then switch back to the voice channel. The data message includes the locomotive ID, target switch ID, and command request. The commands are: normal position and lock; reverse position and lock; status request only; and hold.

When the locomotive is in radio range, the SCS will reply to the cab MITAP with a data message including switch ID, locomotive ID, track circuits status, switch status, command accepted/rejected, and the next switch ID. If a switch movement is requested, and the vital logic checks allow, the control will be executed.

The cab MITAP will continue periodic polling of the SCS, at randomized 10 to 15 second intervals, until end-of-train clearance of the OS track circuit is confirmed.

The SCS will lock the switch for the first train which requests control, and will prevent any other train from controlling the switch until the local track circuits indicate a train has approached and cleared the switch. The locomotive engineer must issue a release command if for some reason he does not traverse the switch.

Occupancy of the OS track will maintain locking, and a track circuit sequence indicating the train has cleared the OS track circuit will release locking after 15 seconds.

After a train passage, with the switch reversed, under either radio or manual control, the SCS will automatically restore the switch to normal position.

If the switch machine is unable to be moved fully and locked into a new position, a pre-set number of retries will be made, followed by returning to the original

position. A "switch obstructed" message will be sent on the next MITAP interrogation.

## 1.3 Operation with Unequipped Trains

To accommodate unequipped trains or in the event of a wayside/locomotive equipment failure, the SCS is equipped with a switch position indicator. The switch position indicator faces each direction to visually confirm switch position and locking for trains unable to communicate with the SCS on the data channel. The indicator is to be approach lit, with a viewing range corresponding to the stopping distance from the restricted approach speed. This distance also corresponds with the approach track circuit length. Conventional relay logic is used to control the indicators. The indicators will be activated by the approach track circuit only if the switch is aligned normal and locked and the train cannot communicate with the SCS via the data channel. The indicator will remain lit while switch locking is in effect. While the indicator is lit the SCS will not accept radio requests for locking. The indicator will be extinguished upon occupancy of the OS track circuit.

## 1.4 System Safety Parameters

The data protocol between the cab MITAP and the SCS is considered vital. Protocol design and error detection techniques ensure ID codes and commands cannot be incorrectly interpreted in a manner which could result in unsafe operation.

Critical data (such as switch ID numbers) is displayed on MITAP at least twice in different areas of the display to preclude errors caused by display failures.

The SCS logic is vital, with default modes of preventing switch operation and lighting of switch position indicators. Switch locking can only be released by passage of a train as detected by the proper sequence of approach and OS track circuits. The logic will prevent action due to momentary loss-of-shunt.

## 2.0 HARDWARE DESCRIPTION

The radio switch hardware is split up into two parts; the cab setup and the wayside setup. These two parts are described in the following paragraphs.

### 2.1 Locomotive Equipment

The locomotive equipment consists of a MITAP unit connected to a CP supplied radio. The block diagram of this equipment is shown in Figure #1.

#### 2.1.1 Cab MITAP

The MITAP-1200 is a mobile information terminal and processor manufactured by Signalcom Canada. This unit is specifically designed for locomotive applications. It replaces the conventional voice radio control head, and adds two-way 1200 bits per second data communications capability. Interface to the locomotive engineer is by a 40 character alphanumeric display and a 4x4 numeric and function keypad.

Three major functions are performed by MITAP-1200:

1. Voice radio control, including control of synthesized transceivers.

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3. Data processing and storage.

For data transmissions the cab MITAP "steals" the radio from the voice channel every 10-15 seconds for a period of approximately 0.5 seconds. The radio is switched to the data channel and data is transmitted and received. The radio is then restored back to the voice channel. The MITAP transmits data over the radio at 1200 baud using fast frequency shift keying (FFSK).

The MITAP is connected to the radio as shown in Figure #3.

### 2.1.2 Cab Radio

The cab radio is a CP supplied GE radio that is presently only used for voice communications. Connecting the radio to the MITAP will allow it to do both data and voice communications. Connection to the MITAP is shown in Figure #3.

## 2.2 Wayside Equipment

The wayside equipment consists of the wayside MITAP, the wayside radio, the wayside MICROLOK and the wayside power switch. A block diagram of this equipment is shown in Figure #1. Most of the wayside components mount in a single 19" rack, the rack layout is shown in Figure #4.

### 2.2.1 Wayside MITAP

The wayside MITAP is manufactured by Signalcom Canada and is similar to the unit used in the cab. The wayside MITAP converts the data stream transmitted over the radio into an asynchronous RS232 form required by the wayside MICROLOK. As little processing as possible is done by the wayside MITAP to ensure data integrity. The MITAP unit is connected to the other components of the wayside setup as shown in Figure #5.

The MITAP transmits data over the radio at 1200 baud using fast frequency shift keying (FFSK). The MITAP talks to MICROLOK at 2400 baud.

### 2.2.2 Wayside Radio

The wayside radio is the MCX100 manufactured by Motorola. This radio will normally be set to the data channel but can be switched to another channel for testing purposes. Connection to the wayside equipment is shown in Figure #6.

### 2.2.3 MICROLOK Description

The wayside MICROLOK is manufactured by Union Switch & Signal. The MICROLOK is responsible for vital control of the power switch and vital interlocking with the track circuits. The MICROLOK has a predefined executive software routine with a user programmable applications program. The MICROLOK is connected to the

wayside MITAP as shown in Figure #5. (For further information see Section 2.3 MICROLOK which describes the operation of the MICROLOK in more detail.)

### 2.2.4 Local Display Panel

The local display panel is used for local display of the switch position and the state of communications. The display panel has three lights. Two lights are used to show normal and reverse correspondence, the third light (comm. light) indicates whether the power switch is in radio communication with a locomotive. When the comm. light is off, this indicates the switch is communicating and under control of a locomotive. (See Figure #7.)

Two lights mounted external of the local display panel were also included to simulate the signal lights at the wayside location.

### 2.2.5 Power Switch

The wayside power switch for field tests is a CP furnished electrically actuated rail switch. The switch performs the actual redirection of the train. The wayside MICROLOK energizes the switch when the switching action is required.

For testing purposes the railway switch will be simulated by a test panel. This test panel will allow for testing both normal and failed conditions of the switch.

### 2.2.6 Test Panel

The test panel simulates the rail switch unit and the approach switches. It is used to test the radio switch system before it is tried in the field. The circuit for the test panel is shown in Figure #9. The test circuit is wired onto a 19" rack panel and is temporarily installed in the MICROLOK rack.

The test panel layout as shown in Figure #8 has the simulated track circuit shown on the front. White indicator lamps indicate the rail switch position and red lamps indicate occupied approach circuits. The test panel also allows a fault to be simulated. This is done by breaking

the feedback path from the switch position indicator.

### 2.2.7 Wayside Battery Connections

To provide both 24VDC and 12VDC, a center tapped 24V battery is used. Both the radio and the MITAP unit require 12VDC; the MICROLOK required 24VDC. Since the radio antenna is connected to the earth ground, this also connects the negative terminal of the battery to earth ground. This is not normal railway grounding convention but further analysis showed it would not present a problem for this application.

## 2.3 MICROLOK

### 2.3.1 MICROLOK Overview

MICROLOK is a microprocessor based logic controller designed specifically for railroad vital interlocking applications. Its basic function is to process various inputs according to a program designed by the applications engineer, and create the appropriate outputs. Inputs and outputs may be through direct interfaces with MICROLOK, or through serial communications with other vital or non-vital controllers. Direct inputs include track circuit occupancy, state of switch machine point contacts, state of signal relay or mechanism contacts, and traffic and line circuits. Outputs eventually interface to control signal mechanism drives, signal lamp drives, switch control contactors or relays and traffic and line control circuits.

Local input options include standard off/on (bit 0/1) voltage inputs in two voltage ranges: 12 or 24 Vdc (nominal). Local output options include standard relay drive or bi-polar relay drive. Special lamp filament compatible outputs are available to drive 18, 25 or 36 watt signal bulbs.

MICROLOK can be linked through serial communications to another vital controller such as another MICROLOK or as in this case a MITAP 1200, using a Master/Slave communications protocol. Communications are formatted to EIA RS-423 standards, and derated to operate under the RS-232C standards.

Detailed information regarding MICROLOK may be obtained from the MICROLOK SERVICE MANUAL 6400 available from Signalcom Canada Corporation.

There is one MICROLOK rack used for the radio switch installation. The rack is made up of a CPU cardfile, an I/O cardfile, a power supply for each cardfile, a MITAP 1200 unit and an MCX100 radio. Data is received over the radio and is serially transferred from the locomotive to the MITAP. The MITAP in turn generates the message with the appropriate protocol and format to send to MICROLOK over the vital serial link. The MITAP acts as the Master and the MICROLOK the Slave. The MICROLOK now acts on this serial data together with the local I/O data to produce final outputs (see below). The MICROLOK also sends a message back to the MITAP with information regarding track occupancy, switch position, next switch ID etc. (refer to the software description). The MITAP then transfers this information to the radio which in turn transmits it to the cab. A brief description of the various MICROLOK PCB's and their use in this system is outlined below.

### 2.3.2 CPU Cardfile PCB's

Processor PCB - The Processor PCB contains the controlling logic of MICROLOK and is required in all applications. The controlling component is an 8-bit microprocessor. It is supported by driver and latch IC's that handle data to and from the CPU cardfile bus. In addition, the Processor PCB contains the "vital-kill" circuitry (analog) responsible for providing or removing power to the microprocessor. The Processor PCB contains one momentary pushbutton used to manually reset the system for troubleshooting.

I/O Bus Interface PCB - The I/O Bus Interface PCB links the computer signals on the CPU motherboard bus with the I/O cardfile. This board contains some of the data interface adapters (PIA's and ACIA) that support the microprocessor on the processor PCB, and various latch and driver IC's for handling data to and from the cardfile bus. The ACIA controls the slave port in a MICROLOK master/slave vital serial link. This PCB also contains the drive circuit that energizes the vital cutoff relay. The I/O Bus Interface card does not contain any user adjustable switches or jumpers.

Peripheral PCB - The Peripheral PCB serves two basic purposes in the MICROLOK computer, and is required in all applications. It enables the MICROLOK to communicate with other MICROLOK or vital controller units as a master (master/slave serial link), and also contains the program memory for the Processor PCB (standard executive and user application). This board is designed to hold a maximum of eight 8K x 8 RAM's or eight 8K x 8 EPROMS, on sockets that accept either type of IC. A single timer module generates interrupts for the vital kill function and the microprocessor watchdog circuit. The Peripheral PCB also contains analog circuits that select the on-line computer in the MICROLOK dual computer version. One ACIA is used for the Master port in the MICROLOK master/slave serial link. LED's display various internal status codes. Switches and jumpers are also mounted on this board for user configuration of the complete Microlok computer.

### 2.3.3 I/O Cardfile PCB's

Standard Input PCB - The Standard Input PCB responds to the presence or absence of voltage, indicating a "one" or a "zero" respectively to the computer. It may be used to monitor eight inputs with single-polarity current, or four bi-polar inputs. Each input includes independent surge protection components, a circuit that provides an input monitor for the CPU computer, and a single opto-isolator for conversion of input signals to board level signals. The Standard Input Board also contains latches for delivering received bits to the motherboard bus, and address decode logic. This board does not contain any field adjustable switches or jumpers. This application monitors the following bits:

OST - OverSwitch Track -
"1" indicates track unoccupied
"0" indicates track occupied

NATR - North Approach Track - same conditions

SATR - South Approach Track - same conditions

STP - Siding Track - same conditions

NWP - Normal Switch Position -
"1" indicates switch normal
"0" indicates switch not normal

RWP - Reverse Switch Position -
"1" indicates switch reverse
"0" indicates switch not reverse

LPR - Lock Repeater Relay -
"1" indicates CP lock relay is energized
"0" indicates CP lock relay is de-energized

The eighth input bit is spare.

Bi-Polar Relay Driver PCB - The Bi-Polar Relay Driver PCB is designed to drive external relays under control of the MICROLOK CPU Computer. This PCB is equipped with three relay drive circuits for operation of bi-polar relays with a minimum of 200 ohm coil resistance. Each driver circuit is capable of delivering a dc voltage in both polarities. Each output circuit consists of two standard relay drive circuits in combination with transistor switching to determine the polarity of the output voltage. The Bi-Polar Relay Driver Board also returns a signal to the computer to indicate that an output has been energized. There are three independent relay drive/verification circuits. Each of these circuits amplifies a precisely cycled signal from the MICROLOK computer to drive a power transistor and, in turn, a transformer. The ac signal from the transformer is rectified and filtered to produce the dc voltage that drives the external relay. An opto-isolator on the transformer secondary is used to return a voltage verification signal back to the computer. This PCB is equipped with latches for handling data on the cardfile bus, and address decode logic. The Bi-Polar Relay Driver PCB does not contain any field adjustable switches or jumpers.

This application controls the following bi-polar output:

LRZR,LNZR

- Lock relay
- positive polarity when the switch is called for in the normal position and is not locked.
- negative polarity when the switch is called for in the reverse position and is not locked.
- no output when MICROLOK determines that the switch should be electicallly locked.

RW,NW

- Switch controls
- Negative polarity will energize the RWR which is used to drive the machine to the reverse position.
- Positive polarity will energize the NWR which is used to drive the machine to the normal position.
- an output should always be present. No output indicates a malfunction.

One spare output is available on this board.

DC Lamp Driver PCB - The DC Lamp Driver PCB is designed to drive standard signal lamps under the control of the MICROLOK Computer. The PCB used in this project is intended for 25 watt 10 volt lamps. A given Lamp Driver PCB is limited to 75 watts total output power (all lamps on at the same time). Thus, not all the outputs on all boards can necessarily be used at the same time.

This board is equipped with four independent lamp driver/verification circuits consisting of transistor drives and optical-isolators. Verification includes (a) determination if voltage has been applied to the lamps, (b) check of the lamp inrush current period, and (c) a hot filament check (current) of individual lamps. The DC Lamp Driver PCB is also equipped with latches for handling data on the cardfile bus, and address decode logic. It does not contain any field adjustable switches or jumpers.

This application uses the following lamp driver outputs:

FL.RED

- Flashes the red signal lamp when the switch is lined and locked in the reverse position and the approach or OS track is occupied.
- Lights the red signal lamp steady when the switch is unlocked and any track is occupied.

FL.GREEN

- Flashes the green signal lamp when the switch is lined and locked in the normal position and the approach or OS track is occupied.

COMLIGHT

- A lamp mounted on the MICROLOK rack to indicate that a train has control of the interlocking via the radio. This lamp is normally lit and goes out once a train establishes communications.

## 2.4 Vital Watchdog Timer

The existing watchdog timer in the MITAP unit had to be redesigned since it was not vital. The existing watchdog could have undetected failed components which would not allow it to shut-down the CPU in the event of a software failure. A new watchdog timer was designed to fit into the space available. It is designed such that any component failure will result in a loss of power to the CPU. With no power to the CPU the MITAP is considered in its fail-safe condition. A schematic of this watchdog is shown in figure #10.

The firmware toggles a watchdog timer every 2 ms (500 hz) to indicate that a vital set of software flags have been set correctly. This output is amplified and fed through a transformer into a vital filter. If any hardware component fails prior to the transformer, then the circuit will go to a steady state condition and a 500 hz signal will not pass through the transformer.

The vital filter is set so that an incoming signal at 500 hz will cause the circuit to resonate and drive the output transformer. The filter has a tolerance of approximately +/-100 hz. This signal is then amplified using the -12v power supply and fed through a second transformer. Again, any failure in the filter section will be blocked by the transformer. A transformer failure is protected against since it is driven from -12v instead of the +5 that the CPU requires. The output of the transformer is rectified and referenced to ground so that the CPU power is supplied by this circuit.

A recover or start switch is incorporated so that the CPU can be started. This is accomplished by a set of charged capacitors that are connected to the -12v supply whenever the recover switch is depressed. The release of the recover switch connects the capacitors to the CPU power supply line. There is sufficient stored energy in the capacitors to run the CPU until it can start toggling the watchdog timer output line.

# 3.0 SOFTWARE DESCRIPTION

## 3.1 Software Overview

The system hardware consists of three distinct and separate pieces: the cab MITAP, wayside MITAP, and the MICROLOK. The communications between these three entities is handled by a vital serial protocol. The cab MITAP to wayside MITAP link employs radio modems, while the wayside MITAP to MICROLOK is through a RS232 link. The cab MITAP does not directly communicate with the MICROLOK. In operation the cab MITAP sends commands and the MICROLOK responds. The wayside MITAP behaves as a buffer between the cab MITAP and the MICROLOK and is used to keep the MICROLOK's vital serial link operational.

### 3.1.1 Cab MITAP Software Overview

The radio switch component of the software performs the following three functions:

I) Human interface: Covers the interaction between the system and the operation.

II) Communications: This covers the buffering, creation of messages, the protocol, commands, and replies.

III) Vital Diagnostic Checks: These (not limited to radio switch process) are a series of diagnostic tests to ensure the correct functioning of the system. Some of the checks are emplaced in parts I) and II).

### 3.1.2 Wayside MITAP Software Overview

The radio switch software performs the following:

I) Communication software: There are two serial communication links handled by this MITAP: the cab to wayside MITAP and the wayside MITAP to MICROLOK.

II) Vital Mitap Diagnostic Checks: These (not limited to the radio switch process) are a series of diagnostic tests to ensure the correct functioning of the system. Some of the checks are emplaced in part I).

### 3.1.3 MICROLOK Software Overview

MICROLOK incorporates two types of software. One is the special application program developed by the application engineer. This program is written of "compiled" on a computer, using a language that enables the system logic to be expressed in a manner relevant to the applications engineer. The finished program is converted into a form that can be burned into EPROM chips used on the MICROLOK Peripheral board. The MICROLOK Development System (M.D.S.) enables the applications engineer to conduct all phases of application program development, including compiling on a personal computer, debugging, scan time estimates, simulating and final programming into the Peripheral board EPROMS.

The second type of MICROLOK software is the standard executive logic common to all MICROLOK systems. This software contains routines designed to (a) verify the states of all vital inputs and outputs, (b) insure that all vital outputs are fully controllable, and (c) remove power to vital outputs in all cases where a system failure has occurred. Vital assurance is applied to local inputs and outputs, and to serial communications with other MICROLOK units or vital controllers. The standard MICROLOK software also performs the input, output and internal logic operations defined in the application engineer's program, as well as diagnostic routines at different operational levels.

## 3.2 Communications Protocol and Packet Format

### 3.2.1 Communications Content

#### 3.2.1.1 Information Content of Cab Message

The following is a list of notable information sent from the cab MITAP through the wayside MITAP to the MICROLOK.

I) Cab or Locomotive Id (identifies point of origin)
II) Switch Id (identifies destination)
III) Direction (up/down the line)

IV) Command (normal, reverse, hold, release, status, monitor)
V) Stage (the current point in the switch communication cycle)
VI) BCH bits (check bits to protect against corruption of message. Based on a form of cyclic redundancy checking)

3.2.1.2 Information Content of MICROLOK Message

The following is a list of the important information sent from the MICROLOK through the wayside MITAP to the cab MITAP.

I) Cab or Locomotive Id (identifies current user of switch)
II) Switch Id (identifies origin of message)
III) Next Switch(es) (number of next switches and the id of the first next switch)
IV) Status (switch position, approach tracks, transit, switch condition, selected route condition)
V) BCH bits (check bits to protect against corruption of message. Based on a form of cyclic redundancy checking)

3.2.2 Communications Stages

Stage I Command Initiation

The cab MITAP sends out a command on the data channel with up to 5 attempts for a valid response. If a valid reply is not received, a communication error is annunciated. Otherwise only the switch id is checked as this is the only meaningful information because Stage II follows immediately.

Stage II Command Confirmation

The cab sends out the command up to 5 times and expects 2 valid responses. If 2 valid responses are not achieved then a communication error is displayed.

Other Checks:

switch id - An error is displayed on the cab MITAP, if the response does not have the expected switch id. This counts as a failed try.

cab id - If the correct cab id is not correct then an error is displayed unless a status is being requested.

switch position - If the switch position is not in requested position then an error is displayed unless a hold or status command has been requested.

route - An error if not clear unless hold, release or status is selected.

switch condition - An error if not ok unless hold, release or status is selected.

At this point if more than one switch is to be controlled, stages I and II will be repeated.

Stage III Monitoring

The cab sends out the command until the transit bit (indicates a train has passed through the switch) has been set or 5 consecutive failed responses or the wayside moves out of correspondence with the cab. Five consecutive bad responses result in a communications failure being annunciated. A failed response can be an incorrect BCH check, no response, or a failure of an appropriate check listed below.

Other Checks

switch id - An error is displayed if the expected switch id is not correct. This counts as a failed try.

cab id - If the cab id is not correct but the switch id is correct then the loss of wayside control is annunciated immediately.

switch position - If the switch is not in requested position an alarm is annunciated immediately.

switch condition
- If the switch condition is no longer correct then an alarm is annunciated immediately.

Stage IV is entered when transit has been set indicating that the train has travelled through the switch. This stage is the idle stage, the wayside is waiting for a command to begin the switching cycle again.

### 3.2.3 Command and Message Sequencing

MITAP, MITAP, and MICROLOK

The system will use about a 500 millisecond "window" to communicate between the cab and the wayside. This window is created by "stealing" 500 milliseconds every 10 seconds or so from the audio usage of the radio.

| Cab MITAP | Wayside MITAP | MICROLOK |
|---|---|---|
| initial handshake | | |
| | determines if message is for wayside | |
| | | sends reply, begins processing command |
| | transmits reply | |
| receives acknowledge sends message | | |
| | received message passed on to MICROLOK with sync and preamble removed and header prefixed | |
| | | MICROLOK receives message, sends out reply |
| | message from MICROLOK has header stripped off and preamble, sync prefixed. Then sends message. | |

| | | |
|---|---|---|
| receives the message from the wayside. Verifies with the message sent out. If same compared with contents of data base I. If same store in data base II. Now have entries in both data bases. Can now display message about actual switch position. Send out prompt with a request for status. This is to monitor OS occupency. Monitors route bit, also | | |
| | receives message. Message passed onto MICROLOK with sync and preamble removed and header prefixed | |
| | | MICROLOK receives message, process message, and sends back reply |
| | message from MICROLOK has head stripped off and preamble, sync prefixed. Then sends message. | |
| receives message. Displays and monitors OS occupancy | | |

.
.
.
.

the above exchange continues
until the transit bit picks

### 3.2.4 Cab MITAP to Wayside MITAP Communications

#### 3.2.4.1 Communication Link Parameters

| | |
|---|---|
| mode: | synchronous |
| baud: | 1200 |
| duplex: | half |
| modulation method: | MSK (FFSK) |
| start/stop bits: | none |
| parity: | none |
| data bits: | 8 |

#### 3.2.4.2 Packet Description

Command Format:

refer to fig 3.2.4.2a

| | |
|---|---|
| preamble: | 16 bits |
| sync: | 16 bits |
| station address: | 8 bits |
| switch number: | 5 digits @ 4 bits per digit |
| cab id: | 5 digits @ 4 bits per digit |

Instructions/Data

| | | | |
|---|---|---|---|
| switch position command: | 2 bits | | |
| | first bit: | | |
| | | 1-normal | 0-not normal |
| | second bit: | | |
| | | 1-reverse | 0-not reverse |
| last message: | 2 bits | | |
| | first bit: | | |
| | | 1-ack | 0-not ack |
| | second bit: | | |
| | | 1-nack | 0-not nack |
| commands I: | 2 bits | | |
| | first bit: | | |
| | | 1-status | 0-not status |
| | second bit: | | |
| | | 1-release | 0-not release |
| direction: | 2 bits | | |
| | first bit: | | |
| | | 1-up | 0-not up |
| | second bit: | | |
| | | 1-down | 0-not down |

```
        commands II:    3 bits
                        first bit:
                                1-hold          0-not hold
                        second bit:
                                1-clear id      0-not clear id
                        third bit:
                                1-monitor       0-not monitor

        stage:          3 bits
                        in stage one 1-TRUE      0-FALSE
                        in stage two 1-TRUE      0-FALSE
                        in stage three 1-TRUE    0-FALSE

packet number:          4 bits

packing:                22 bits

protection:             3 bytes BCH  code

total:                  144 bits


Reply Format:

refer to fig 3.2.4.2b

preamble:               16 bits
sync:                   16 bits
station address:        8 bits
cab id:                 5 digits @ 4 bits per digit
switch id:              5 digits @ 4 bits per digit
switch count:           2 bits
                        first bit:
                        1-single        0-not single
                        second bit:
                        1-double        0-not double
wayside status:         10 bits
        switch position:
                        first bit:
                        1-normal        0-not normal
                        second bit:
                        1-reverse       0-not reverse
        up approach track:
                        third bit:
                        1-occupied      0-not occupied
        down approach track:
                        fourth bit:
                        1-occupied      0-not occupied
```

```
                overswitch status:
                                fifth bit:
                                1-occupied      0-not occupied
                siding approach track:
                                sixth bit:
                                1-occupied      0-not occupied
                transit:
                                seventh bit:
                                1-true          0-false
                route:
                                eighth bit:
                                1-clear         0-not clear
                switch obstructed:
                                ninth bit:
                                1-true          0-false
                next switch type:
                                one bit:
                                1-hand          0-power
        packing:                4 bits
        packet number           4 bits
        next switch id:         5 digits @ 4 bits per digit
        protection:             3 bytes BCH code
        total:                  144 bits
```

Description of the Above
---

Preamble: A pattern of 16 bits used by the modem to establish bit synchronization. The pattern is 1010101010101010.

Sync: A pattern of 16 bits used to establish byte synchronization in the MITAP. The pattern is 1100010011010111.

Station Address: A byte containing the Station Address of the intended port and some control bits. This is the same for all radio switch MICROLOKs. The 5 LSBs indicate the station address, the MSB indicates master to slave acknowledgement, and the rest are not used and will be zero.

Switch Number: This identifies the wayside installation and is related to route and mileage.

Cab Id: This identifies the cab installation.

Direction: This allows the wayside equipment to determine the direction of travel so that the cab may be informed of the next switch(es).

Last Message: This is to inform the wayside that the cab received the last packet sent to it. In the case of the initial prompt the bits will be set to ack, not nack.

Wayside Status: This set of nine bits are used to tell the cab what is happening at the wayside.
The first two bits indicate the switch position.
The third bit the condition of the up approach track.
The fourth bit the condition of the down approach track.
The fifth bit indicates the condition of the overswitch.
The sixth bit indicates the condition of the siding track.
The seventh bit indicates whether there has been a recent transit of the overswitch.
The eighth bit indicates the condition of the requested route.
The ninth bit indicates whether the switch was moved successfully.

Packet Number: Not Used.

Stage: Indicates the communication stage of the cab MITAP. Used to indicate to MICROLOK the state of the system in case MICROLOK has gone through a reset.

Next Switch Id: These 20 bits are meant to identify the next switch. A switch id of FFFFF indicates that the MICROLOK has failed.

Packing: These are extra bits inserted for expansion.

Protection: This is a three byte BCH calculated for a message size of 256 bits.

Switch Count: These bits are used to indicate the number of switches that will be with in radio range next. This allows the cab MITAP to prompt the operator as to whether or not to control just the next switch or the next two switches.

Switch Position Control: These two bits are used to tell the wayside what position to align the switch. The first bit is used to set the switch to normal. The second bit is used to set the switch to reverse.

Commands I: The first bit would cause the MICROLOK to put out the current status of the wayside. The second bit is used to allow the MICROLOK to be released from the current cab id so that another cab may use the wayside.

Commands II: The first bit is used to signal the wayside that an approach track is to be occupied but not to lock up the wayside waiting for a plant transit to occur. The second bit is reserved and is always zero. The third bit is for hand throw switches and indicates to the wayside that there is a train in constant communication.

| NUMBER OF BITS | | | | | | | | 144 BITS TOTAL |
|---|---|---|---|---|---|---|---|---|
| >16 | 16 | 8 | 20 | 20 | 14 | 4 | 22 | 24 |
| PREAMBLE | SYNC | SWITCH ADDRESS | SWITCH NUMBER | CAB ID | INSTRUCTION OR DATA | PACKET NUMBER | PACKING | BCH |

FIGURE 3.2.4.2a MITAP TO MITAP COMMAND FORMAT

| NUMBER OF BITS | | | | | | | | | | 144 BITS TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|
| >16 | 16 | 8 | 20 | 20 | 2 | 10 | 4 | 4 | 20 | 24 |
| PREAMBLE | SYNC | STATION ADDRESS | CAB ID | SWITCH ID | SWITCH COUNT | WAYSIDE STATUS | PACKING | PACKET NUMBER | NEXT SWITCH ID | BCH |



FIGURE 3.2.4.2b MITAP TO MITAP REPLY FORMAT

| NUMBER OF BITS | | | | | | | 120 BITS TOTAL |
|---|---|---|---|---|---|---|---|
| 8 | 8 | 20 | 20 | 14 | 4 | 22 | 24 |
| HEADER | STATION ADDRESS | SWITCH NUMBER | CAB ID | INSTRUCTION OR DATA | PACKET NUMBER | PACKING | BCH |

FIGURE 3.2.5.2a MITAP TO MICROLOK COMMAND FORMAT

| NUMBER OF BITS | | | | | | | | | 120 BITS TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| 8 | 8 | 20 | 20 | 2 | 10 | 4 | 4 | 20 | 24 |
| HEADER | STATION ADDRESS | CAB ID | SWITCH ID | SWITCH COUNT | WAYSIDE STATUS | PACKET NUMBER | PACKING | NEXT SWITCH ID | BCH |

FIGURE 3.2.5.2b MITAP TO MICROLOK REPLY FORMAT

### 3.2.5. Wayside MITAP to MICROLOK

#### 3.2.5.1 Communication Link Parameters

| | |
|---|---|
| mode: | asynchronous |
| baud: | 2400 |
| duplex: | full |
| data encoding method: | NRZ |
| start/stop bits: | 1/1 |
| parity: | none |
| data bits: | 8 bits |

#### 3.2.5.2 Packet Description

Command Format:

refer to fig 3.2.5.2a

| | |
|---|---|
| header: | 8 bits |
| station address: | 8 bits |
| switch number: | 5 digits @ 4 bits per digit |
| cab id: | 5 digits @ 4 bits per digit |

Instruction/Data

| | | | |
|---|---|---|---|
| switch position | | | |
| command: | 2 bits | | |
| | first bit: | | |
| | 1-normal | | 0-not normal |
| | second bit: | | |
| | 1-reverse | | 0-not reverse |
| last message: | 2 bits | | |
| | first bit: | | |
| | 1-ack | | 0-not ack |
| | second bit: | | |
| | 1-nack | | 0-not nack |
| commands I: | 2 bits | | |
| | first bit: | | |
| | 1-status | | 0-not status |
| | second bit: | | |
| | 1-release | | 0-not release |
| direction: | 2 bits | | |
| | first bit: | | |
| | 1-up | | 0-not up |
| | second bit: | | |
| | 1-down | | 0-not down |

```
                    command II: 3 bits
                                first bit:
                                1-hold              0-not hold
                                second bit:
                                1-clear id          0-not clear id
                                third bit:
                                1-monitor           0-not monitor
                    stage:      3 bits
                                in stage one    1-TRUE  0-FALSE
                                in stage two    1-TRUE  0-FALSE
                                in stage three  1-TRUE  0-FALSE

        packet number:          4 bits
        packing:                22 bits
        protection:             3 bytes BCH  code
        total:                  120 bits

Reply Format:

        refer to fig 3.2.5.2b


        header:                 8 bits
        station address:        8 bits
        cab id:                 5 digits @ 4 bits per digit
        switch id:              5 digits @ 4 bits per digit
        switch count:           2 bits
                                first bit:
                                1-single        0-not single
                                second bit:
                                1-double        0-not double
        wayside status:         10 bits
                switch position:
                                first bit:
                                1-normal        0-not normal
                                second bit:
                                1-reverse       0-not reverse
                up approach track:
                                third bit:
                                1-occupied      0-not occupied
                down approach track:
                                fourth bit:
                                1-occupied      0-not occupied
                overswitch status:
                                fifth bit:
                                1-occupied      0-not occupied
                siding approach track:
                                sixth bit:
                                1-occupied      0-not occupied
```

| | | |
|---|---|---|
| transit: | | |
| | seventh bit: | |
| | 1-true | 0-false |
| route: | | |
| | eighth bit: | |
| | 1-clear | 0-not clear |
| switch obstructed: | | |
| | ninth bit: | |
| | 1-true | 0-false |
| next switch type: | | |
| | 1 bit: | |
| | 1-hand | 0-power |
| next switch id: | 5 digits @ 4 bits per digit | |
| packet number: | 4 bits | |
| packing: | 4 bits | |
| protection: | 3 bytes BCH code | |
| total: | 120 bits | |

Description of the Above
---

Header: A sequence of 8 bits expected by and generated by MICROLOK to pass over initial noise. The pattern is 10101010. This is not protected by the BCH. The balance of the bit fields are as described in 3.2.4.

## 3.3 Cab MITAP

### 3.3.1 Description of Cab MITAP

The cab will provide for entry of direction, switch id, command selection, switch position, and through or hold for tandem switches. The cab will send out its data approximately once every 12.5 seconds. The time between messages will be pseudo-random and fall somewhere between 9-15 seconds. This will ensure that two cab MITAPs do not continuously interfere with each others transmission. This sending out of the data be viewed as occurring in distinct stages.

Problems Annunciated

1) COMMUNICATION FAILURE
   no response after a specified number of tries.
   Any stage. Detected by time out.

2) SWITCH IN USE undefined

3) ROUTE NOT CLEAR
indicates that MICROLOK cannot line and lock the route.

4) SWITCH OBSTRUCTED
indicates that MICROLOK tried to move the points but could not.
Stage 2. Detected by switch obstructed TRUE.

5) BAD SWITCH POSITION
indicates that MICROLOK has failed to move the switch to the correct position. Reason unknown.
Stage 2. Detected as switch position in data base not equal to reply position.

6) CANNOT RELEASE
indicates that wayside has not accepted release command. Detected by the transit bit not going TRUE.

7) SWITCH IS TALKING TOO
indicates that another cab already has control of the plant. A cab id of 0000 is a special cab id and indicates that the MITAP has reset.
Detected by different cab id in the response message.

3.3.2 Major Code Groupings (for Cab MITAP)

1) Cab MITAP Human Interface

I) Drivers
II) Processing
III) Ancillary processing
IV) Human Interface to Communications

2) Cab Communications

I) Serial Drivers
II) Error Checking (BCH)
III) Retry Handling
IV) Multiple Tries
V) Message Building
VI) Data Base Maintenance and Message Dissassembly
VII) Communications to Human Interface

3) Vital Code

I) BCH generator
II) Op code testing (conditional jumps)
III) RAM and ROM checks

## 3.4 Wayside MITAP

### 3.4.1 Description of Wayside MITAP

Turning on the power causes all the buffers and flags to be initialized.

| | | |
|---|---|---|
| 3 buffers | rad$rx$message | - data stream coming from radio |
| | tx$message | - data to send out to MICROLOK |
| | rad$tx$message | - stores data stream from MICROLOK if enabled will then be sent out the radio |
| flag | sends$to$cab | - allows the contents of BUFFERB to be transmitted |

On power up a dummy message will be loaded into tx$message. This message will be set for a cab and switch id of FFFFF. All other bits are set to zero, except BCH. This is necessary to keep the vital link operational during the period before a valid message is received. A message received is checked for BCH and correct switch id. If the BCH and switch id is correct the flag send$to$cab is set so that MICROLOK's response will be transmitted otherwise the system waits for the next message. The contents of rad$rx$message is loaded into tx$message unless the message has the status command bit set then the previous message is left in tack. At this point a flag is set enabling transmission to MICROLOK and the radio is turned around for transmission of the response. When the MITAP beings to receive a message from MICROLOK it checks to see if sends$to$cab to see if it is to send out the response. If it is, the MITAP immediately initiates radio transmission. Upon completion of the MITAP sending a message to the cab it will turn the radio back to receiving.

### 3.4.2 Wayside MITAP Human Interface

I) Drivers
II) Processing - local control (+ regular MITAP?)
III) Ancillary processing
The wayside MITAP would have some message processing so that it can indicate its current status.

2) Wayside Communications - Radio Protocol
I) Serial Drivers
II) Address Checking
III) Buffering - a ring buffer
NOTE: A) The buffer would be a ring buffer to ensure that the messages are being continously over written and since it is possible to make the buffer smaller than the message then there will never be a complete message in memory.

3) Wayside MITAP - MICROLOK Protocol
I) Drivers
II) Buffering
III) Checking - framing
IV) Retry Handling
V) Timeouts

4) Vital Code
I) BCH generator
II) Op code testing (conditional jumps)
III) RAM and ROM checks

## 3.5 MICROLOK Application Program

A detailed description of the MITAP software including the MICROLOK message, various communications stages, protocol makeup etc. is described elsewhere. This description relates only to the MICROLOK application program. The description covers how the incoming message is handled, how the signalling logic works and how the outgoing message is generated. Descriptions will relate to the actual bit names used in the program.

### 3.5.1. Incoming Message from MITAP

This message consists of 80 bits as described below.

SWIN1 to SWIN20 - Switch ID grouped in five 4 bit segments with each segment representing a decimal digit in equivalent Hex form. Thus 1001 would represent the digit 9. All combinations except FFFFF are allowable. The switch ID is used by the engineman to access a particular location.

CABIN1 TO CABIN20 - Cab ID grouped in five 4 bit segments similar to the switch ID. All combinations except 00000 and FFFFF are allowable. The Cab ID is used to tell the wayside which engine is communicating with it.

NOR - Normal switch request.

REV - Reverse switch request.

ACK - Not used in this application.

NACK - Not used in this application.

STATUS - Used by the MITAP only.

RELEASE - Request to cancel a previously issued NOR or REV command. Used in the event the engineman wants to change his route due to a change of orders. This command essentially releases the switch locking.

UP - Request for a route in the UP direction (increasing mileage).

DOWN - Request for a route in the DOWN direction (decreasing mileages).

HOLD - To be used for tandem switches. Not used in this application.

CL.ID - Not used in this application.

MONITOR - Used at Hand-throw locations only.

STAGEI - This bit is automatically generated by the MITAP and is used by the MICROLOK for detecting a new valid message.

STAGEII - From the MICROLOK point of view this bit is exactly the same as a STAGEI bit.

STAGEIII - This bit is again automatically generated by the MITAP and is used by the MICROLOK only in the event of a communications failure.

All the other bits on the serial line are spares.

### 3.5.2 Outgoing Message to MITAP

This message is also made up of 80 bits as described below.

CABOUT1 to CABOUT20 - Cab ID. This is a reply from the MICROLOK telling the CAB that it has stored the correct Cab ID. It is made up of five 4 bit segments similar to the incoming Cab ID.

SWOUT1 to SWOUT20 - Switch ID. This is a reply from the MICROLOK telling the CAB that it has accessed the correct location. It is made up of five 4 bit segments similar to the incoming Switch ID.

SINGLE - Tells the Cab that this is a single switch location.

DOUBLE - Tells the Cab that this is a double switch location. This bit will be used in future applications.

NWK - Normal Switch Indication. "1" indicates that the switch is in the normal position and is in correspondence with the normal request. "0" indicates that the switch is either not in the normal position or that the switch position does not correspond with a normal request.

RWK - Reverse Switch Indication. "1" indicates that the switch is in the reverse position and is in correspondence with the reverse request. "0" indicates that the switch is either not in the reverse position or that the switch position does not correspond with a reverse request.

NATK - North Approach Track Indication.
"1" indicates that the track is occupied.
"0" indicates that the track is unoccupied.

SATK - South Approach Track Indication.
"1" indicates that the track is occupied.
"0" indicates that the track is unoccupied.

OSOCC - OverSwitch Occupied.
"1" indicates that the OS track is occupied.
"0" indicates that the OS track is unoccupied.
STK - Siding Track Indication.
"1" indicates that the track is occupied.
"0" indicates that the track is unoccupied.

TRANSIT - This bit goes high to tell the Cab that:
(a) An equipped train has gone through the interlocking and the OS track has picked back up, or
(b) A release function has been acted upon by the wayside.

ROUTE - This bit is normally low and goes high to tell the Cab that a route has been lined and locked by the wayside.

SWBLK - Switch Blocked. This bit goes high when the switch loses correspondence for more than 20 seconds. This should only happen if the switch points become obstructed (for instance due to snow accumulation).

SWTYPE - This bit goes high to tell the Cab that the next switch is a Hand Throw Switch.

NXSWOUT1 to NXSWOUT20 - Next Switch ID. Grouped into five 4 bit segments similar to the Switch ID. Used tell the Cab what the next Switch ID is.

### 3.5.3 Program Logic

The logic will be described in the same order as it is listed in the program.

Define slow pick tracks: Track bits are assigned a set time to allow for a loss of shunt. For example, if a train is occupying the OST then the OST and the OSTP will be low. If the train momentarily loses shunt (say due to rusty rails) we do not want this to have any effect on the logic (such as releasing the switch locking). Consequently a set time of 5 seconds is assigned to the OSTP essentially making it equivalent to a slow pick relay. Now the OST must be high for 5 seconds before the OSTP goes high. The OSTP is used in the majority of the logic.

Power Up Routine: The power up routine is designed so that the MICROLOK logic resets to a predetermined sequence

of events every time. Provided all tracks are unoccupied the INITIAL bit will be set high by a 1 second reset pulse generated by (~MLK.RS * MLK.BRS). The INITIAL bit in turn requests a normal switch as well as setting the LEAVE bit. Once this is accomplished the INITIAL bit is cleared and stays low until another reset occurs.

Switch ID: The stored switch ID for this location is 00397. The incoming switch ID is compared to the stored switch ID by means of the SW.ONE and SW.ZERO bits (first checking that the switch ID is not all 1's). If a proper comparison is made then a SW.ID bit is set.

Cab.ID: CABONE detects if the incoming Cab ID is all ones. CABZERO detects if the incoming Cab ID is all zero's. If either condition is met than BADCAB will be generated. A new Cab ID is stored in bits C1 through C20 provided SW.ID is high. C1...C20 are held or stuck through LVCOMP * ~BADCAB. LVCOMP checks the LEAVE bit low or the COMPARE bit high. This holds the Cab ID in storage until a transit has occurred and a new Cab ID has been received. The COMPARE bit sets when the Cab ID received on the serial link agrees with the stored Cab ID in C1...C20. The Compare bit in turn sets the CAD.ID bit which is then stuck through the LEAVE bit low. The CAB.ID bit is used to enable switch requests and is also used to block out any new Cab ID's coming in on the serial link from being stored.
CABIDTER is merely a buffer used for timing considerations.

Leave or Transit: The LEAVE bit is essential to the proper operation of the logic. This bit can be set in one of three ways:

1. On power up it is set by the initial bit once the OS track and lock are set.
2. It can be set by any of the three directional sticks once the OS track and lock bits reset after the passage of a train.
3. It can be set by the RELEASE bit provided the COMPARE bit is high.

The LEAVE bit is stuck in one of three ways:

1. Through the continual receipt of the last StageIII message from MITAP (~STG1.TER * ~STG2.TER).
2. Through the RELEASE bit high.
3. Through the (~ROUTE * ~STG3.TER * COMMFAIL) path. This path is used in the event that the ROUTE bit has been set but a StageIII message is never received by the Cab due to a communications failure. If the train is allowed to proceed any way there must be a way to hold up the LEAVE bit even though the last message being received from

the field MITAP is a StageI or a StageII message. The next equipped train will clear the LEAVE bit and reset the system.

Switch Requests: To set the NORMAL bit the following checks are done: NOR must be high indicating a request on the serial link. CAB.ID and SW.ID must both be high. REV must be low (opposing request check). LEAVE must be low. LEAVE will go high with the passage of a train. This will effectively block the NOR bit which will still be present on the serial link. LR must be high to indicate that the interlocking is free to use.

On power up the INITIAL bit will set the NORMAL bit. The NORMAL bit is stuck through the REVERSE bit low. Thus an opposing request will cancel a stored request. The REVERSE bit is set in a similar manner except that it is not set by the INITIAL bit.

Route Requests: To set the UPREQ bit the following checks are done: UP.TER must be high indicating a request on the serial link. DOWN must be low. (opposing route) CAB.ID and SW.ID must be high. LEAVE must be low. (similar philosophy to switch request) INITIAL must be low and MLK.BRS must be high to prevent a false request on power up. STOP must be low. This bit sets with the OS track low or the RELEASE bit high and essentially "slots off" the route request. DNREQ must be low. (opposing check). UPREQ is stuck through the ~STOP * ~DNREQ path so that once it is set, the only way to slot it off is through the STOP bit or the opposing request being set. The DNREQ is set in a similar manner.

Preliminary Route Check: To set the UHSPR the following checks are made: UPREQ must be high indicating a route request from an equipped train or if UPREQ is low then the approach track must be down with the opposing directional sticks low. This path is used to trigger a route request from an unequipped train. DNREQ and DHSPR must be low (opposing checks). OSTP must be high (OS track unoccupied). The switch must be in correspondence

((NWC * ~RWC) + (RWC * ~NWC)).
NAT must be high unless UPSTICK is high. This would be similar to a following move situation but is actually used by the departing train to throw the switch back normal after a reverse move.
DHSPR is set in a similar manner.

Route Clearing: The appropriate route bit URR or DRR is set with the Preliminary Route Check bit high, the OSTP high and the LR low (indicating that the switch machine is electrically locked).
Directional Sticks: The directional sticks are set by the appropriate approach track going low together with the OS track going low. They are held through the OS track and the appropriate trailing track low. Checks are also made to ensure that the opposing sticks are down.

Switch Position Indicators:
EOR is a flasher bit (1/2 sec on, 1/2 sec off) actuated by any track down.
DNLIGHTN through UPLIGHTR set with the appropriate switch position and route called for and the appropriate approach track or OS track down.
FL.GREEN flashes the Green lamp.
FL.RED flashes the Red lamp provided RED is low. When RED is high (indicating the switch is unlocked) then the Red lamp will be steady lit.

The remaining part of the software generates the output message to MITAP which was discussed above.

## 3.6 Existing MITAP Software

The radio switch software will interface with software already developed for the MITAP. This is a summary of the linkages anticipated.

i) The cab MITAP program is entered through the existing menu routine.

ii) The Channel Select and Call IN routines will be used as in the standard MITAP. An exception occurs when the cab is trying to communicate with the wayside. In this case abbreviated forms of the commands are displayed to permit more space to display the radio switch commands.

iii) Other used modules include reading the keyboard and data entry routines to the human interface to retain consistency with the existing products.

iv) Timers are added and the wait routine changed to allow monitoring of the keypad and serial ports.

v) The serial routines are adopted from the existing code.

vi) The stack is moved as it resides in memory that has been earmarked for the data base.

vii) A special display routine has been created for the system annunciating the actual status of the switch. This is to allow the system to do checks as the words reverse and normal must not appear in their entirety anywhere except on the display.

viii) All routines that are used in a vital section have been rewritten or placed in a 'wrapper' calling routine to ensure its correct operation.

# 4.0 FAILSAFE OPERATION

## 4.1 MICROLOK Failsafe Features

MICROLOK is a vital microprocessor-based interlocking control system which processes all trackside vital inputs as well as both office and field generated non-vital inputs. The vital inputs include such items as track circuits and switch correspondence. Standard signal circuits are converted to logic statements by a simple procedure and stored into a programmable read only memory (PROM). The microprocessor in the MICROLOK system will apply the logic contained in the PROM to both the vital and non-vital inputs and produce outputs which will control the trackside equipment such as switch machines and signals.

A system is said to be vital if faults cause the system to fail to a predictable or known state. In MICROLOK, faults of the system cause the outputs to fail to the "off" or zero state. In this manner, signals fail to dark and switch machines do not move. This is equivalent to gravity causing the contacts of a vital relay to open or break its circuit when failures occur.

The MICROLOK system utilizes "closed loop" principles to ensure system vitality. With a unique monitoring system, the microprocessor is able to examine the state of each output. If a particular output should fail in any state (on or off), the monitor will alert the microprocessor to the failure so that corrective action can take place. In a similar manner, MICROLOK insures the integrity of each safety-related input.

In order to insure that infrequently used outputs are operational, MICROLOK momentarily flips each output to the opposite state. During this time, which is typically a fraction of a millisecond, the microprocessor, through the monitor observes the behaviour of the output. This switching of outputs is brief enough that devices being controlled do not respond, yet the speed of the microprocessor is such that it can easily observe the change.

To insure the correct operation of the internal microprocessor system, MICROLOK performs self-diagnostics. As a result of these diagnostics, a toggling 500 hz signal is generated. This 500 hz signal drives a circuit that generates a voltage to energize the "vital cut-off" contactor. Contacts of

the vital contactor provide the only source of power for the output circuitry. Failure of any diagnostic will stop the 500 hz toggle signal resulting in the de-energization of the vital contactor. The contacts will open and remove power from all output circuitry.

## 4.2 MITAP Failsafe Features

Vitality:

Detection of a failure in the system is vital to ensuring the safety in the system. Emphasis has been placed during the design stage to structure the parts of the program such that checks are an important part of the overall design. The result has been a complex interdependant system of checks, whose own complexity provides a measure of protection. The implication of this is that the program is checking itself throughout and not just in a few routines.

Data Structure Checks:

These checks will often come in the form of comparison between two values from two separate data bases. The data bases contain the information transmitted to MICROLOK and information received from MICROLOK. These data bases are an important part of the program's vitality as the data bases exist in two separate RAMs and the data base exist at addresses that are a prime number apart thus requiring more than a single address line failure to cause the processor to access the same data twice rather than the two separate data bases. This also performs a simple RAM check in that it checks for known values. In addition to verifying the data as needed, a complete compare will be done between the two data bases when the two data bases should be congruent. Data bases are also checked after receiving two complete and correct messages and before annunciating the position of the switch has been confirmed. Any unexpected deviation from the expected message after that would be immediately annunciated. Whenever possible two actions are required to represent an event or command. For example, switch position: two boolean flags are used for switch position, they are REVERSE and NORMAL. The following table shows the possible combinations and the meaning of a command or received response.

| REVERSE | NORMAL | INTERPRETATION |
|---|---|---|
| False | False | Command: Don't change switch position some other command sent.<br>Response: Position unknown - an error condition |
| False | True | Command: Set switch to Normal<br>Response: Switch is in normal |
| True | False | Command: Set switch to reverse<br>Response: Switch is in reverse |
| True | True | Command: A 'can't happen'. System has failed.<br>Response: A 'can't happen'. System has failed. |

Algorithm Checks:

The flow of the program is to be as heavily monitored as processor time will allow. This will be done by using a combination of a password and semaphores. The password is a more complex sequence of bytes. The passwords not only permit entry into selected states but also contain a history of the execution. This password is 'built' during execution of the program and its predictability and usability is made possible by the use of a state driven machine. This use of a state driven machine also allows a semaphore check to be used between the non-maskable tick timer and the state driver. This allows the two separate processes to check that each other appears to be running and are not stuck in some sort of loop. This is done by the use of a semaphore. The interrupt routine checks to see if the semaphore has been set. If the semaphore has set then it is cleared. If it has not been cleared after so many attempts then an error would be generated. Similarly the state driver would set the semaphore if it is detected as cleared. It too will generate an error if after so many tries the semaphore has not been cleared.

Program:

Actual routines for checking the correctness of the system will also be implemented. These include a routine to check the data base RAM. There will be routines to exercise selected op codes to detect if these op codes are operating properly. The communication messages as they are built within their respective buffers will have their 3 byte BCH code built at the same time. The BCH code will be appended to the end of the buffer when the message has been written to the buffer. There will also be a

complex series of stored checksums for the EPROM. The EPROM is broken into a 179 x 181 byte byte for checksum calculations. Checksums are calculated for both rows and columns and sums of of those sums are also calculated. These sums are all compared against values stored in EPROM.

Hardware:

The hardware protection will consist of a watchdog timer. Should this timer time out it will reset the hardware on the system thus clearing the display so that non valid messages would not remain on the display.

Additional Checks Within the System:

The following comprise checks that are used to detect errors in the system but, do not inherently increase the vitality of the system as vital checks, that is a failure does not necessarily cause a degradation of the system but rather limits the system in its actions. These items are built into the communications protocol. The communication message is of fixed length and format. The message also contains within it the transmitting station ID and the intended receiving station ID. This is to allow decisions about who is talking to whom. The commands consist of multiple bits implying that if more than one is set then the system has in someway failed. The timing windows for responses in the protocol are limited so provide an additional check.

## 5.0 IN HOUSE TESTING

Extensive inhouse testing was done on the radio switch setup before it was installed in the field. The testing was done in stages and they are described below.

The first item tested was the communication link between the wayside MITAP and the MICROLOK unit. The difficult part of this communication link was to program the MITAP to respond as a MICROLOK on the communication link. This needed to be done since the MICROLOK executive was programmed to communicate in a fixed fashion. This allowed us to test the BCH error checking protocol since MICROLOK will only respond to a correct BCH value. A few software bugs were discovered and corrected. The error detecting capability of the BCH code when used in this system was calculated and it was determined that the fault detection is more than required.

The second item tested was the syncronous communication link between the wayside MITAP and the cab MITAP. A two wire link

was connected between the two MITAPS. The communication mode was programmed and the communication link was established. A program was written to monitor the success of the communication link and it was discovered that there was a 99.9% success rate which is one miss out of 1000 communications.

The third test was a complete system test with two wires in place of the radio communication link. With this setup we tested the logic in MICROLOK as well as the functionality of the cab MITAP. A test panel was built to simulate the track circuits in the field as well as the movement of the switch machine. At this time the system was working to the point that the cab MITAP could throw the power switch via a two wire link.

The fourth test consisted of transmitting the data via the radios but keeping the radios within the lab. Dummy loads were connected to the radios to absorb the RF energy. A few problems were encountered in the link between the wayside MITAP and the wayside Motorola radio. This problem arose since the GE radio and the Motorola radios are not compatible. A modification to the wayside MITAP's communicated via the radio link.

With the cab and the wayside communicating via radio the cab MITAP was put in the back of a car and some testing was done while the cab was under motion. This test also gave us an indication of the range of the radio communication link. It was discovered that the range of the system was approx. 7km.

There was also some concern that the error checking protocol would be to rigorous to allow for RF noise. Testing indicated that the data message range was the same as for normal voice communications. When fading and popping prevented normal voice communication then data communication also stopped. When voice communications were marginal the data usually got through.

Testing in the field has shown that data communication message success rate is approx. 80% 90%. This success rate is more than adequate for proper radio switch operation.

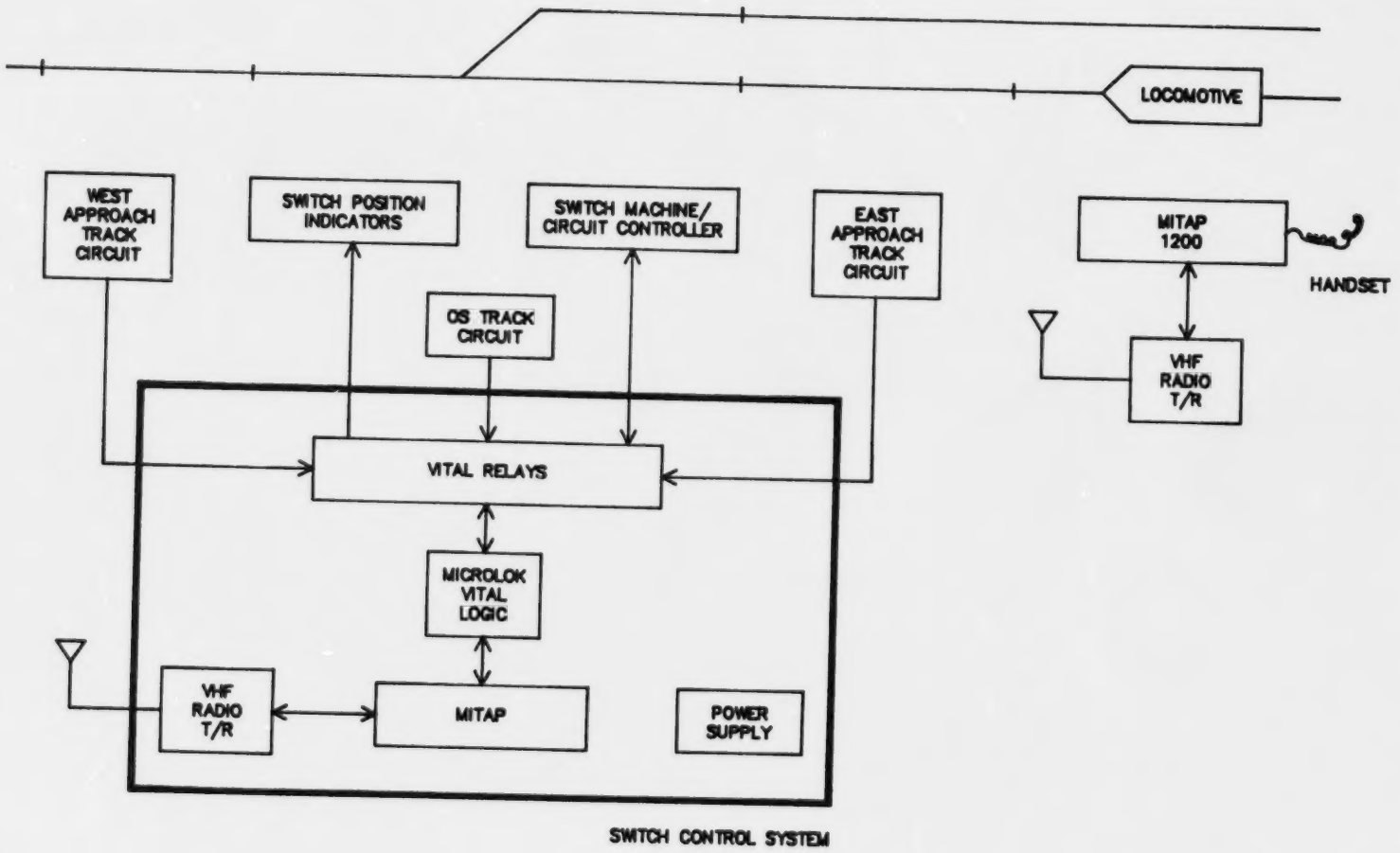
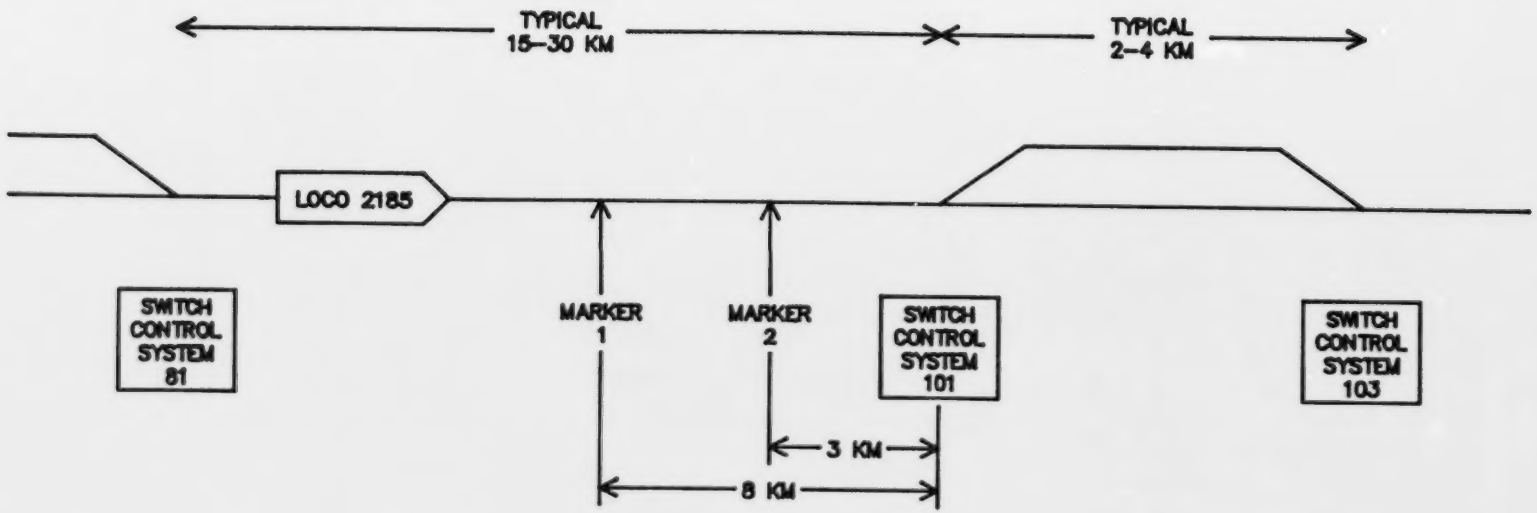



FIG. #1 MBS TERRITORY RADIO OPERATED POWER SWITCH CONTROL SYSTEM BLOCK DIAGRAM




MARKER 1: INITIATE RADIO REQUEST

MARKER 2: PREPARE TO STOP IF CONFIRMATION NOT RECEIVED

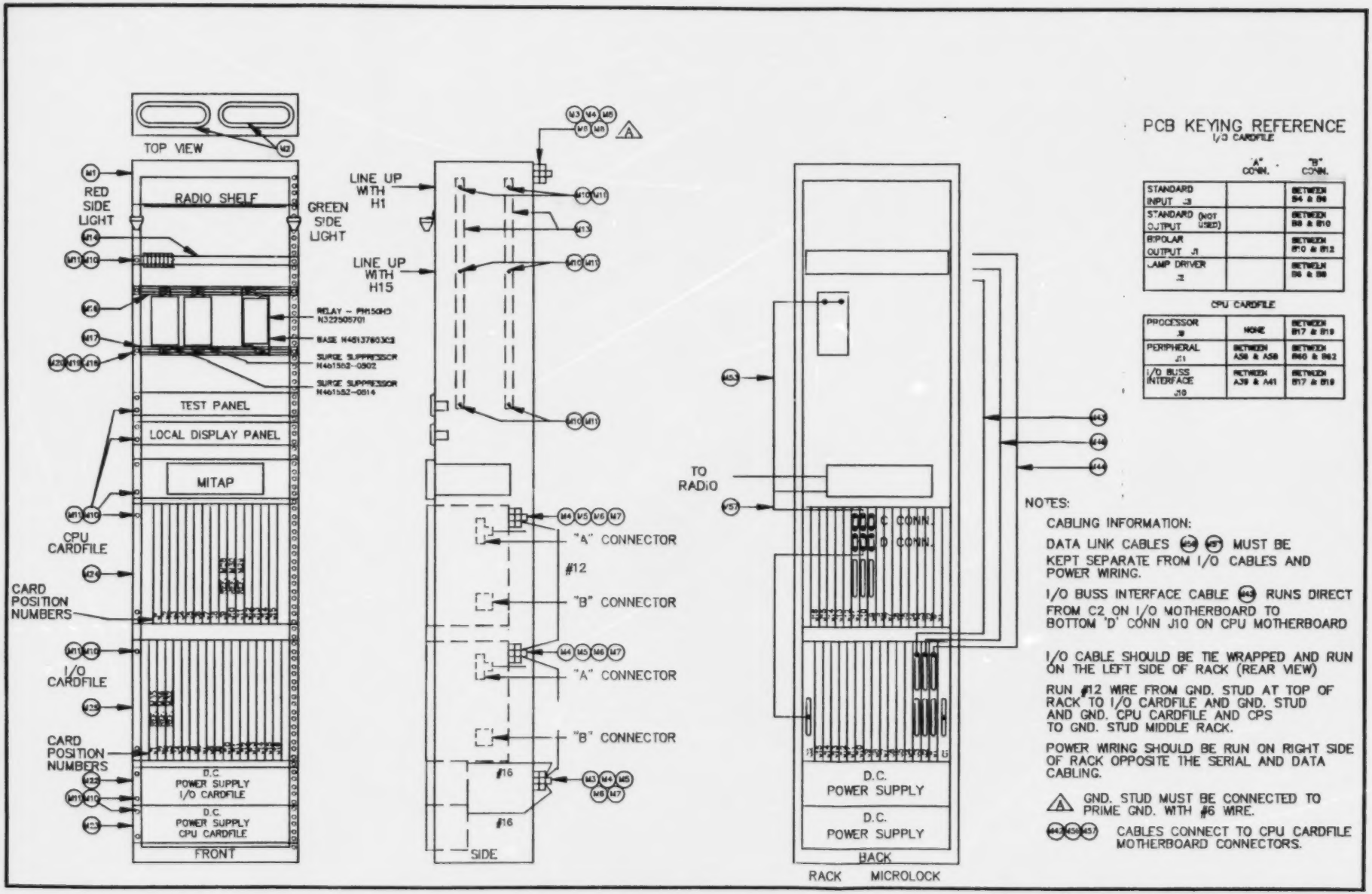
FIGURE–2. RADIO OPERATED POWER SWITCH CONTROL SYSTEM OVERVIEW

| FUNCTION | MITAP CONNECTOR PIN | GE RADIO MOUNTING BASE |
|---|---|---|
| Blank | A, B, C, D | - |
| Ground | E | 5 |
| Mic Shield | F | 6 |
| Mic Hi | G | 7 |
| Rcvr Audio Hi | H | 8 |
| Push to Talk | J | 9 |
| F1, Freq. Control 1 | K | 10 |
| F2, Freq. Control 2 | L | 11 |
| F3, Freq. Control 3 | M | 12 |
| F4, Freq. Control 4 | N | 13 |
| Blank | P, Q, R, S | - |
| Oscillator Return | T | 18 |
| Blank | U, V | - |
| Pos. 13.6 Volts | W | 21 |
| Blank | X, Y | - |
| RF Sensor | Z | 24 |

NOTE:

1. Connect 8 ohm 10W resistor between mounting base pins 5 and 8.
2. If RF sensor is not available, jumper Z to J or 24 to 9.

FIGURE #3 MITAP 1200 CONTROL HEAD CONNECTOR WIRING




PCB KEYING REFERENCE
I/O CARDFILE

| | "A" CONN. | "B" CONN. |
|---|---|---|
| STANDARD INPUT J3 | | BETWEEN B4 & B6 |
| STANDARD OUTPUT (NOT USED) | | BETWEEN B8 & B10 |
| BIPOLAR OUTPUT J1 | | BETWEEN B10 & B12 |
| LAMP DRIVER J2 | | BETWEEN B6 & B8 |

CPU CARDFILE

| | | |
|---|---|---|
| PROCESSOR J9 | NONE | BETWEEN B17 & B19 |
| PERIPHERAL J11 | BETWEEN A58 & A58 | BETWEEN B60 & B62 |
| I/O BUSS INTERFACE J10 | BETWEEN A39 & A41 | BETWEEN B17 & B19 |

NOTES:

CABLING INFORMATION:

DATA LINK CABLES (#56) (#57) MUST BE KEPT SEPARATE FROM I/O CABLES AND POWER WIRING.

I/O BUSS INTERFACE CABLE (#45) RUNS DIRECT FROM C2 ON I/O MOTHERBOARD TO BOTTOM 'D' CONN J10 ON CPU MOTHERBOARD

I/O CABLE SHOULD BE TIE WRAPPED AND RUN ON THE LEFT SIDE OF RACK (REAR VIEW)

RUN #12 WIRE FROM GND. STUD AT TOP OF RACK TO I/O CARDFILE AND GND. STUD AND GND. CPU CARDFILE AND CPS TO GND. STUD MIDDLE RACK.

POWER WIRING SHOULD BE RUN ON RIGHT SIDE OF RACK OPPOSITE THE SERIAL AND DATA CABLING.

(A) GND. STUD MUST BE CONNECTED TO PRIME GND. WITH #6 WIRE.

(#43)(#56)(#57) CABLES CONNECT TO CPU CARDFILE MOTHERBOARD CONNECTORS.

FIGURE #4 RADIO SWITCH – WAYSIDE RACK

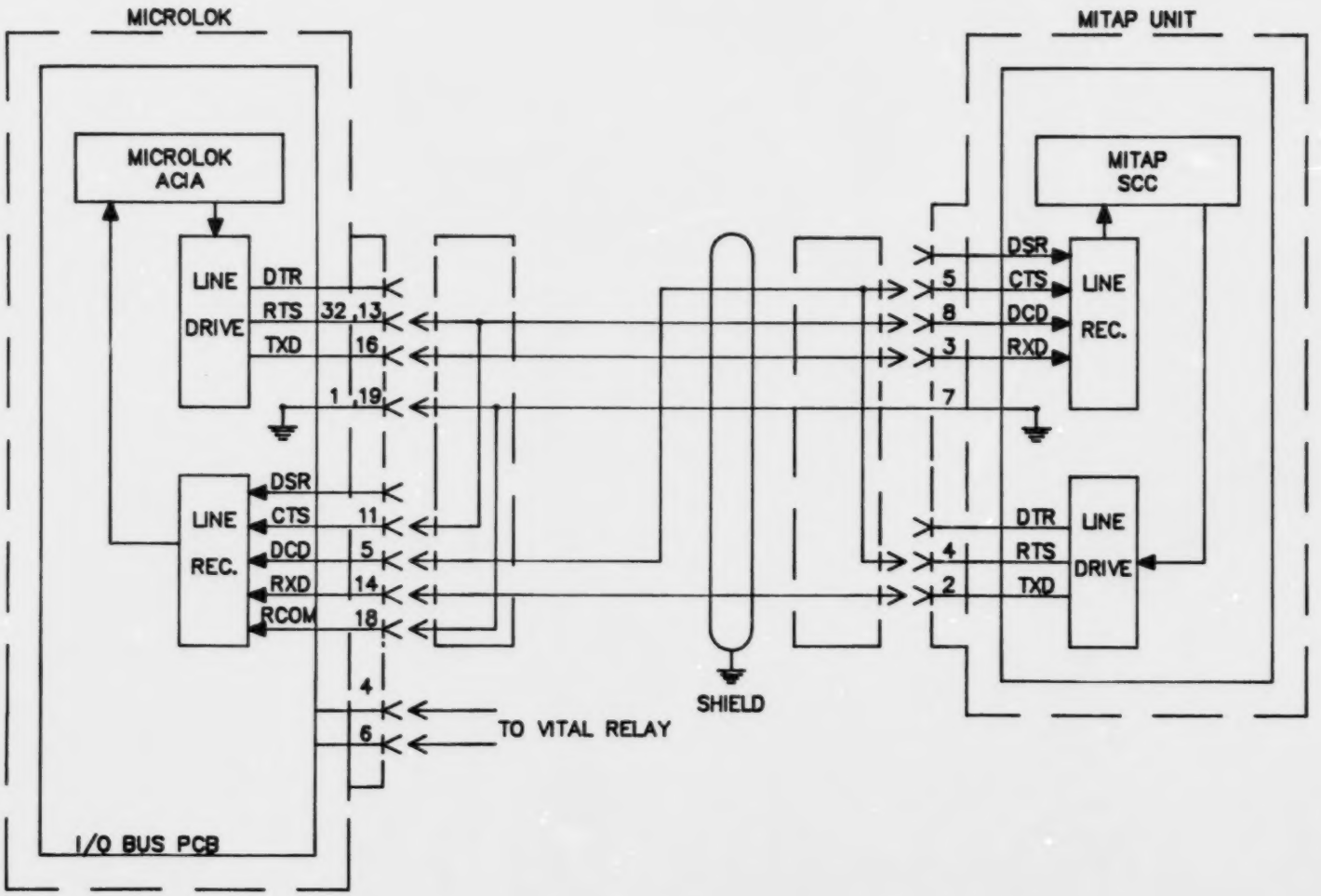



FIG. #5 MICROLOK/MITAP VITAL SERIAL LINK DWG. MIC-1

| FUNCTION | MITAP CONNECTOR PIN | MCX100 RADIO |
|---|---|---|
| Blank | A, B, C, D | - |
| Ground | E | Battery |
| Mic Shield | F | 34 Black |
| Mic Hi (Out) | G | 8 Red |
| Rcvr Audio Hi (In) | H | 17 Blue |
| F0, Freq. Control 0 | J | 12 White |
| F1, Freq. Control 1 | K | 13 Yellow |
| F2, Freq. Control 2 | L | 14 Orange |
| F3, Freq. Control 3 | M | 15 Brown |
| F4, Freq. Control 4 | N | 16 Violet |
| Blank | P, Q, R, S | - |
| Freq. Control Return | T | 10 Grey |
| Blank | U, V | - |
| Pos. 13.6 Volts | W | Battery |
| Blank | X, Y | - |
| Squelch/Power Switch | Z | 32 Green |

FIGURE 6 MITAP 1200
CONNECTOR WIRING

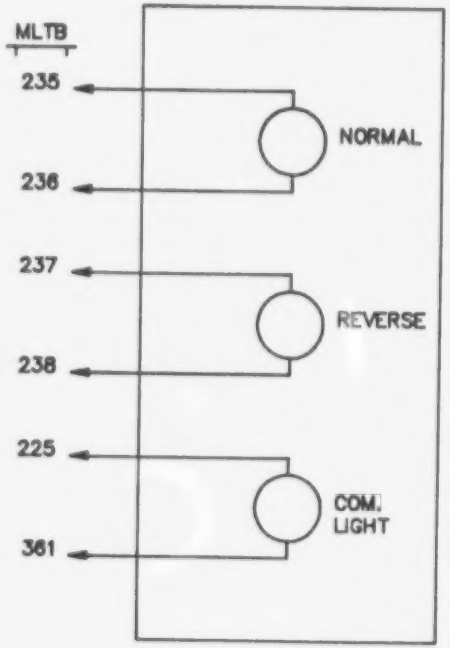



FIGURE #7 – LOCAL DISPLAY PANEL

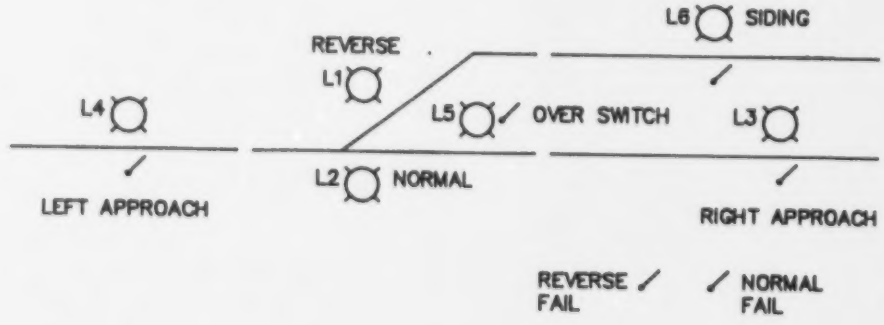



FIGURE #8 – TEST PANEL LAYOUT

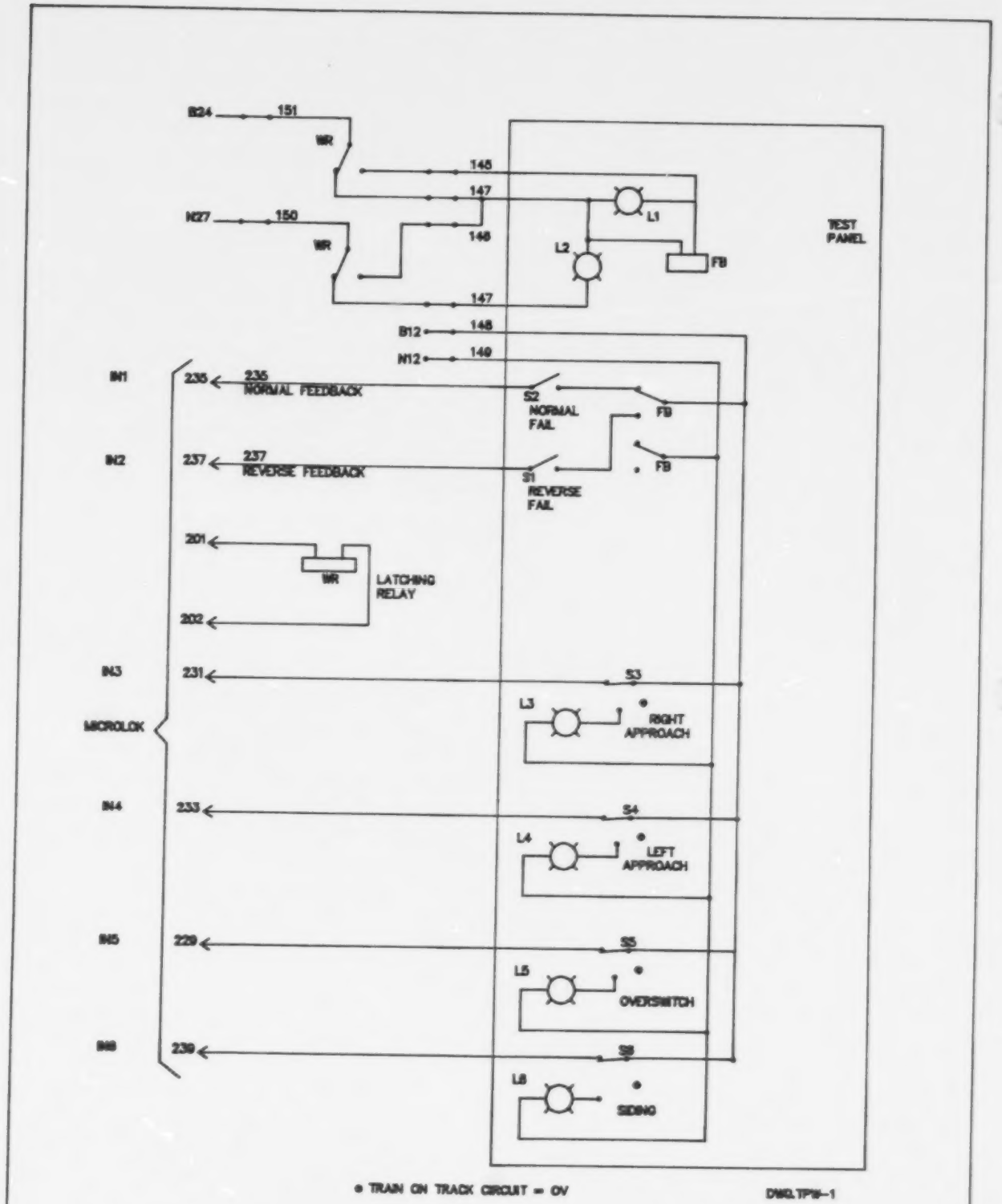
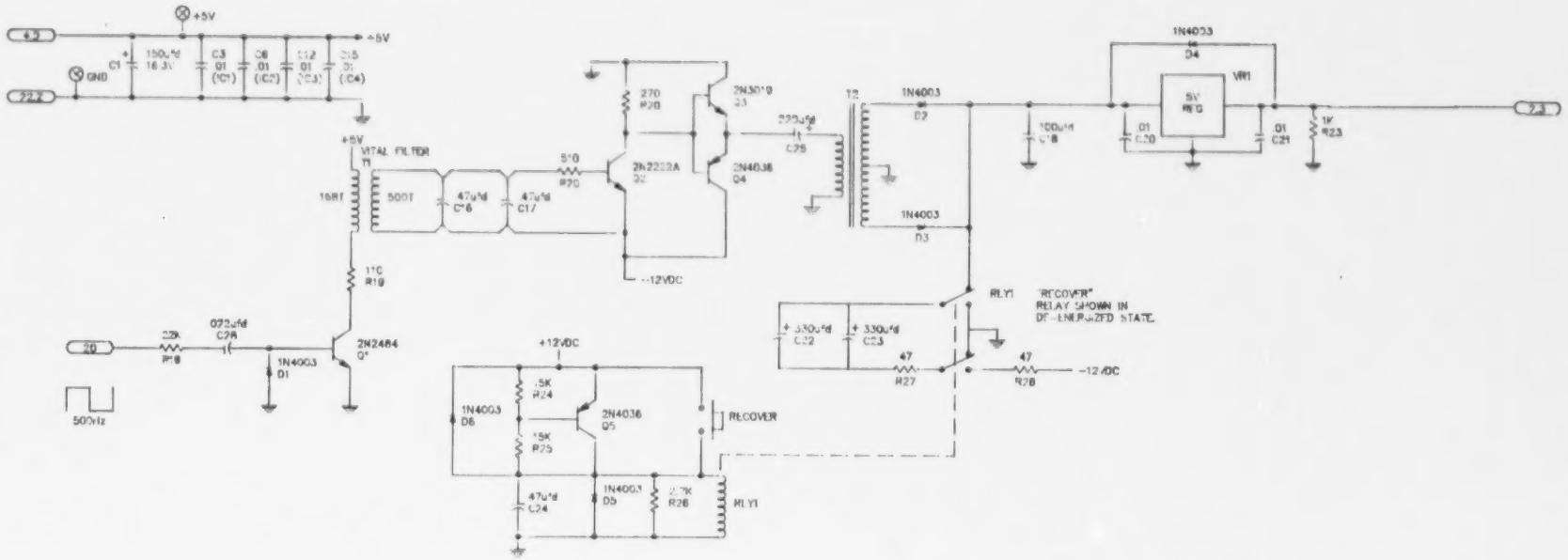



FIG. #9 TEST PANEL WIRING DIAGRAM




| REVISIONS | |
|---|---|
| DEC 12/86 | SCHEMATIC CORRECTIONS |

PRIOR TO BEING PLACED IN REGULAR SERVICE, THE OPERATION OF ANY CIRCUITS AND EQUIPMENT PRESENTED HEREIN MUST BE CHECKED BY CIRCUIT SELECTION (BREAKDOWN) AND SERVICE (OPERATION) TESTS OF THE COMPLETE SYSTEM OR SECTION OF SUCH A SYSTEM INTO WHICH THEY ARE CONNECTED.

| | DATE |
|---|---|
| DWN DWK | 9 30 86 |
| CHKD DJL | 10 2 86 |
| O.K. | |

VITAL WATCHDOG TIMER
DWG. T209H-B

SIGNALCOM CANADA CORPORATON
6 INDELL LANE
BRAMPTON, ONTARIO L6T 3Y3

SH. 1

FIGURE #10

# APPENDIX I

# CAB MITAP GENERIC DISPLAYS

# SECTION I

## Generic Displays

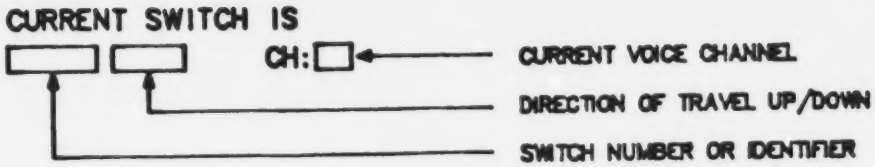



Fig 1.

Fig 1: This is a display of the default switch as it exists upon entry to the radio switch.

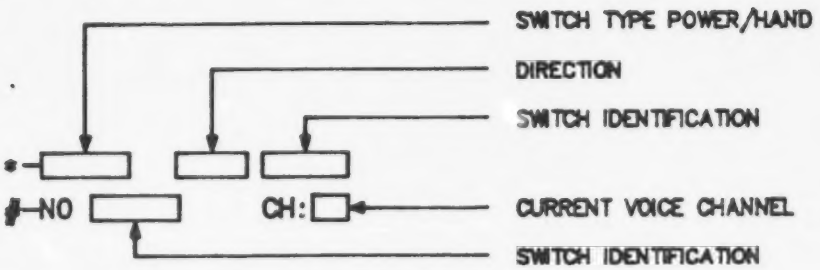



Fig 2.

Fig. 2 This display is a prompt to accept or reject the switch parameters that exists in the cab MITAP.

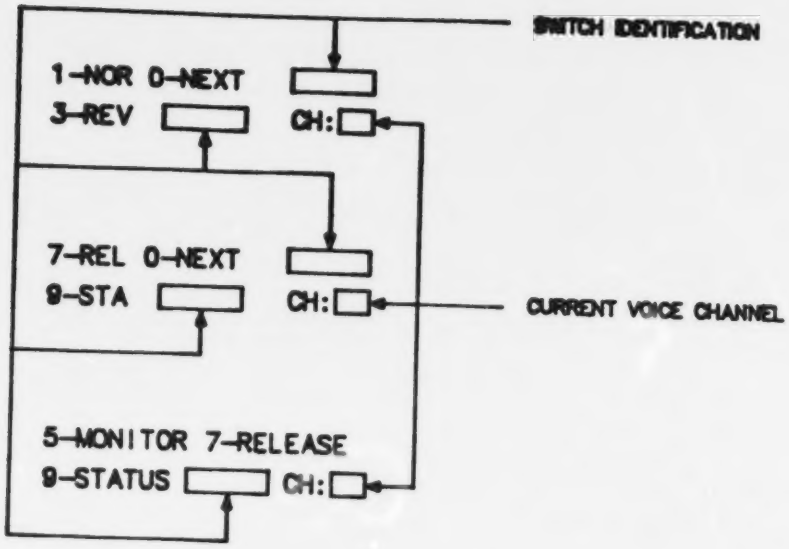



Fig 3.

Fig. 3 These three displays represent the selections of commands available to the operator. A power switch has 4 options associated with it, these being reverse, normal, release, and status. As only two of these options are displayed at one time, the command next is used to show the two options not displayed.

A manual switch has three options associated with it, these are monitor, release, and status.

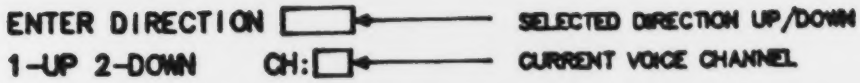



Fig 4.

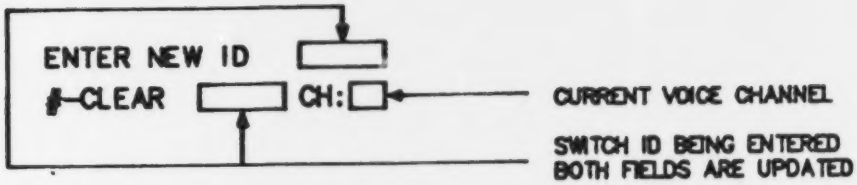



Fig 5.

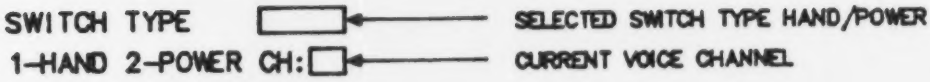



Fig 6.

Fig. 4, 5, 6 are associated with the manual entry of switch parameters.

Fig. 4 is the display in which a new direction can be entered. The field in the upper right hand corner of the display indicates the selected direction.

Fig. 5 is the display in which a new switch is entered.

Fig. 6 is the display in which the type of switch can be entered. The field in the upper right hand corner of the display indicates the selected type.

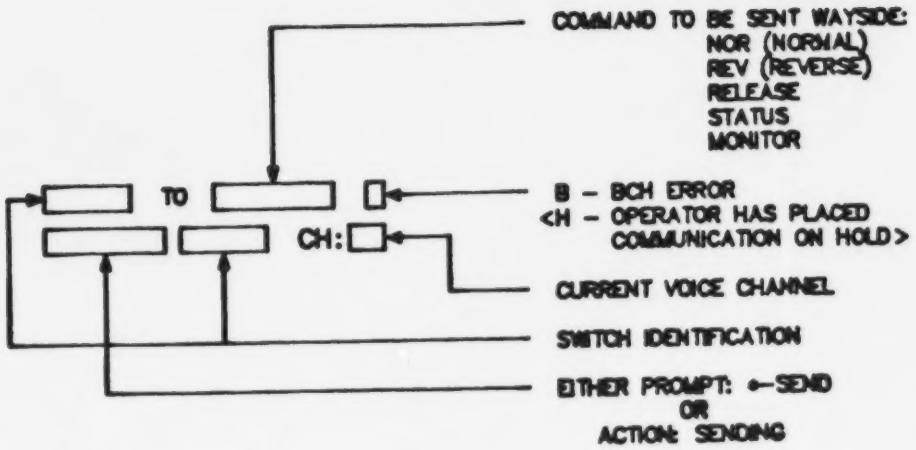



Fig 7.

Fig. 7 This display is the prompt to begin sending the selected command. The field in the lower left corner is changed from *-SEND to SENDING when transmission begins.

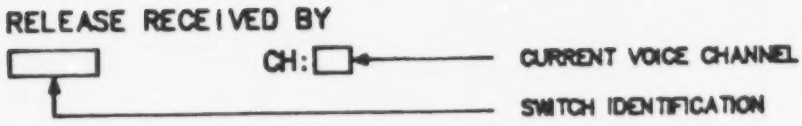



Fig 8.

Fig. 8 This display appears after successful communication of the release command to the wayside. It does not indicate that the release was acted upon.

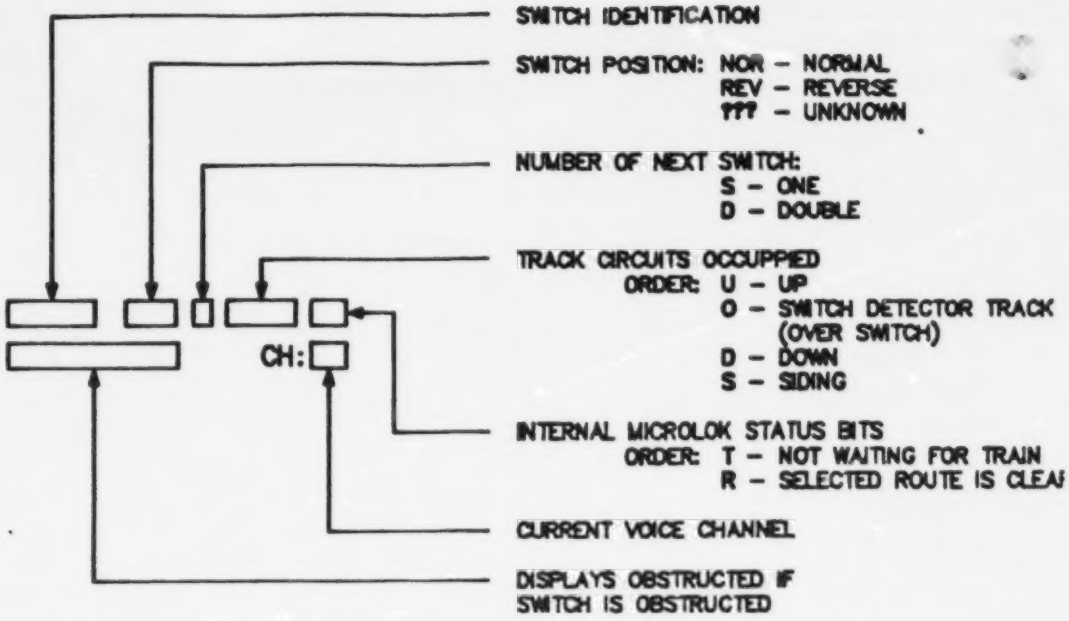



Fig 9.

Fig. 9 This display appears after a status command reply has been received. It tells the current situation at the plant.

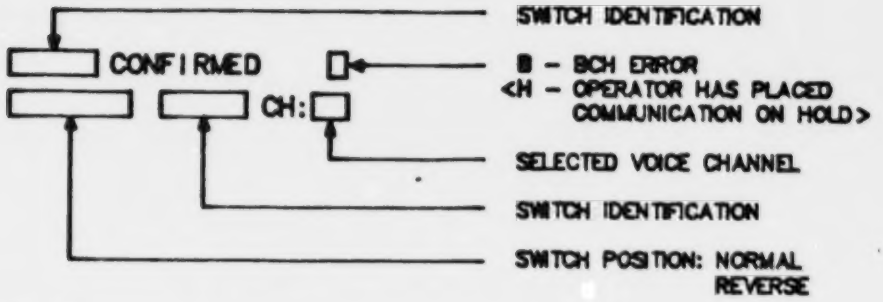



Fig 10a.

Fig. 10a This display appears after two successful responses from the wayside and must appear before the safe braking distance to the switch is reached.

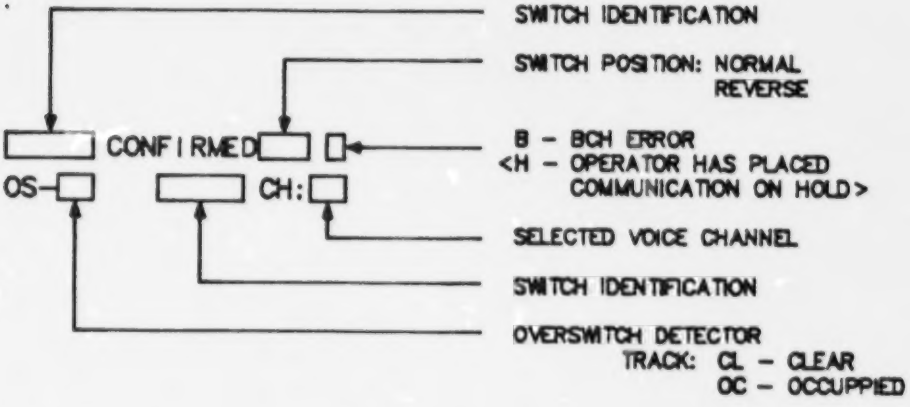



Fig 10b.

Fig. 10b This display remains on the display after 10a has appeared barring an error until the train has completely crossed over the switch. The field in the lower left indicates the condition of the overswitch detector track.

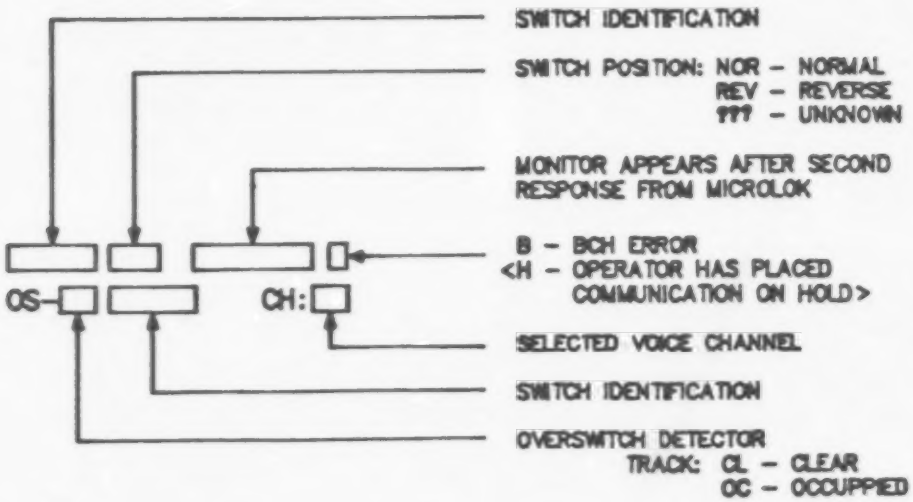



Fig 11.

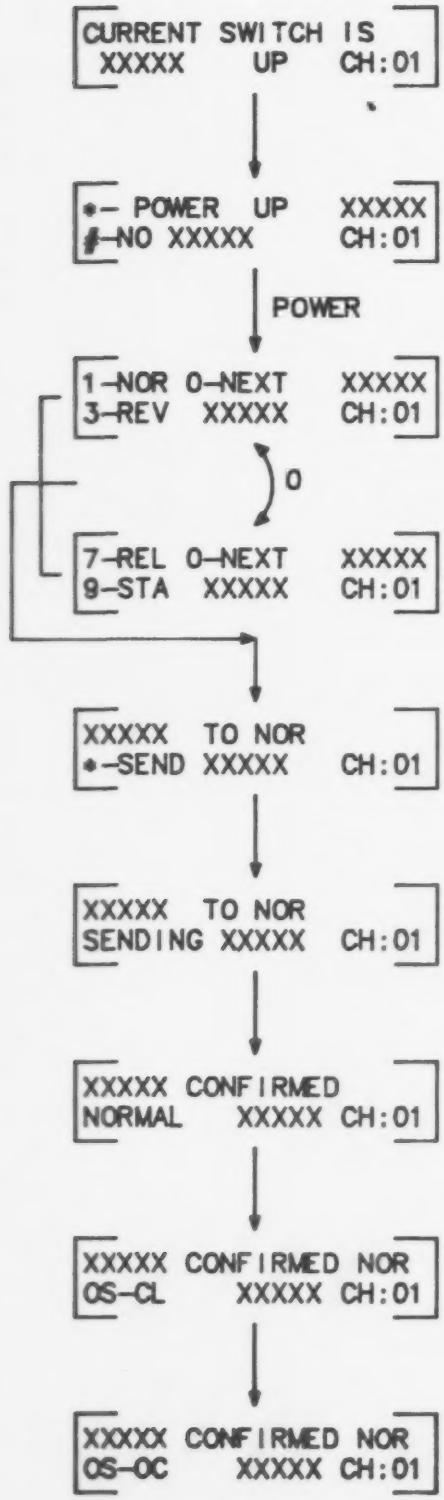
Fig. 11 This display is for the monitoring of a handthrow switch. The switch position is displayed in the middle of the upper line and the OS occupancy in the lower left of the display.

# SECTION II

## Examples

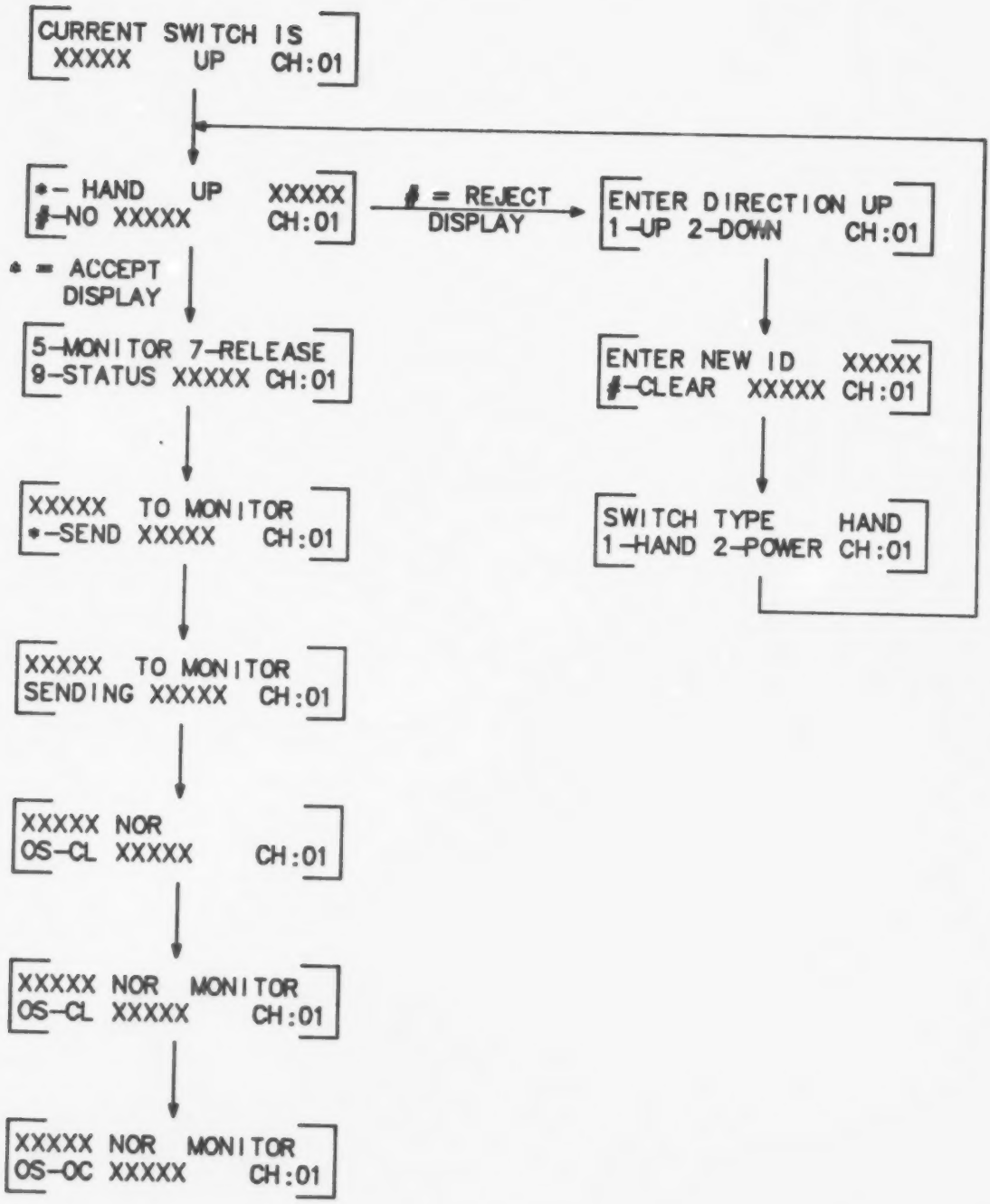
This first example is a power switch operation. The operator accepts the current switch, checks his/her options, selects normal, sends the command and then monitors the OS track for the train to go through.

# NEXT POWER SWITCH



The second example is a handthrow switch operation with the displays for changing the switches characteristics shown. Otherwise, the operation is quite similar to the power throw switch.

# NEW HAND SWITCH

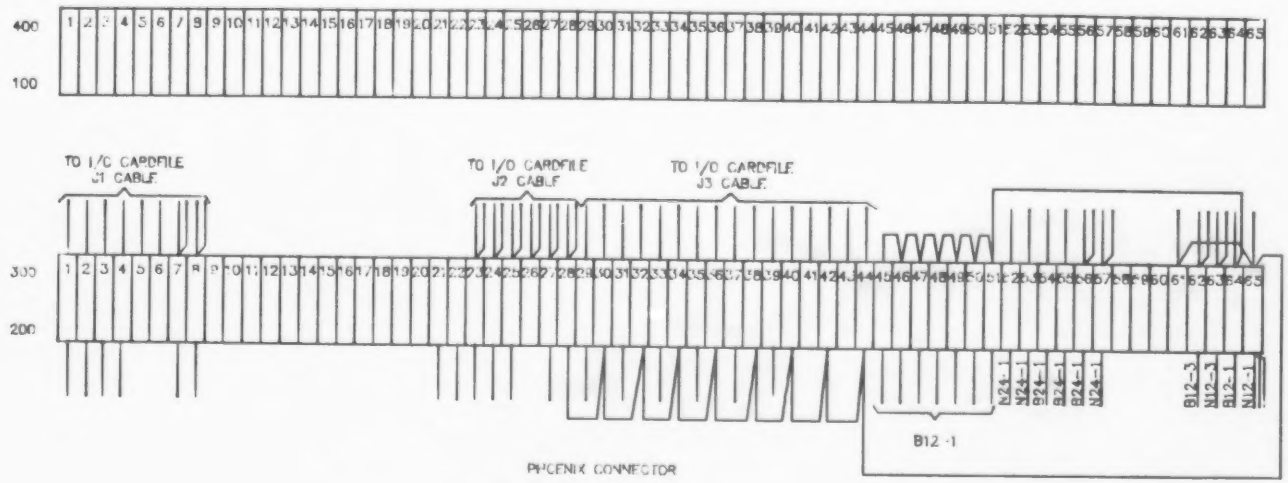


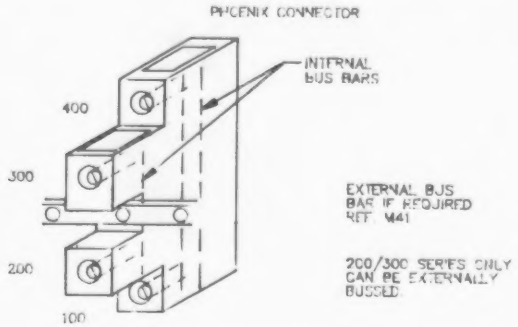
# APPENDIX II

CP RAIL RADIO SWITCH CONTROL

TEST INSTALLATION DRAWINGS

RED DEER, ALBERTA




MICROLOK TERMINAL BOARD

| REVISIONS | | |
|---|---|---|
| AS INSTALLED NOV 12 '96 | | |

PRIOR TO BEING PLACED IN REGULAR SERVICE, THE OPERATION OF ANY CIRCUITS AND EQUIPMENT PREVENTED HEREON MUST BE CHECKED BY CIRCUIT SECTION (BREAKDOWN) AND SERVICE (OPERATION) TESTS OF THE COMPLETE SYSTEM OR SECTION OF SUCH A SYSTEM INTO WHICH THEY ARE CONNECTED

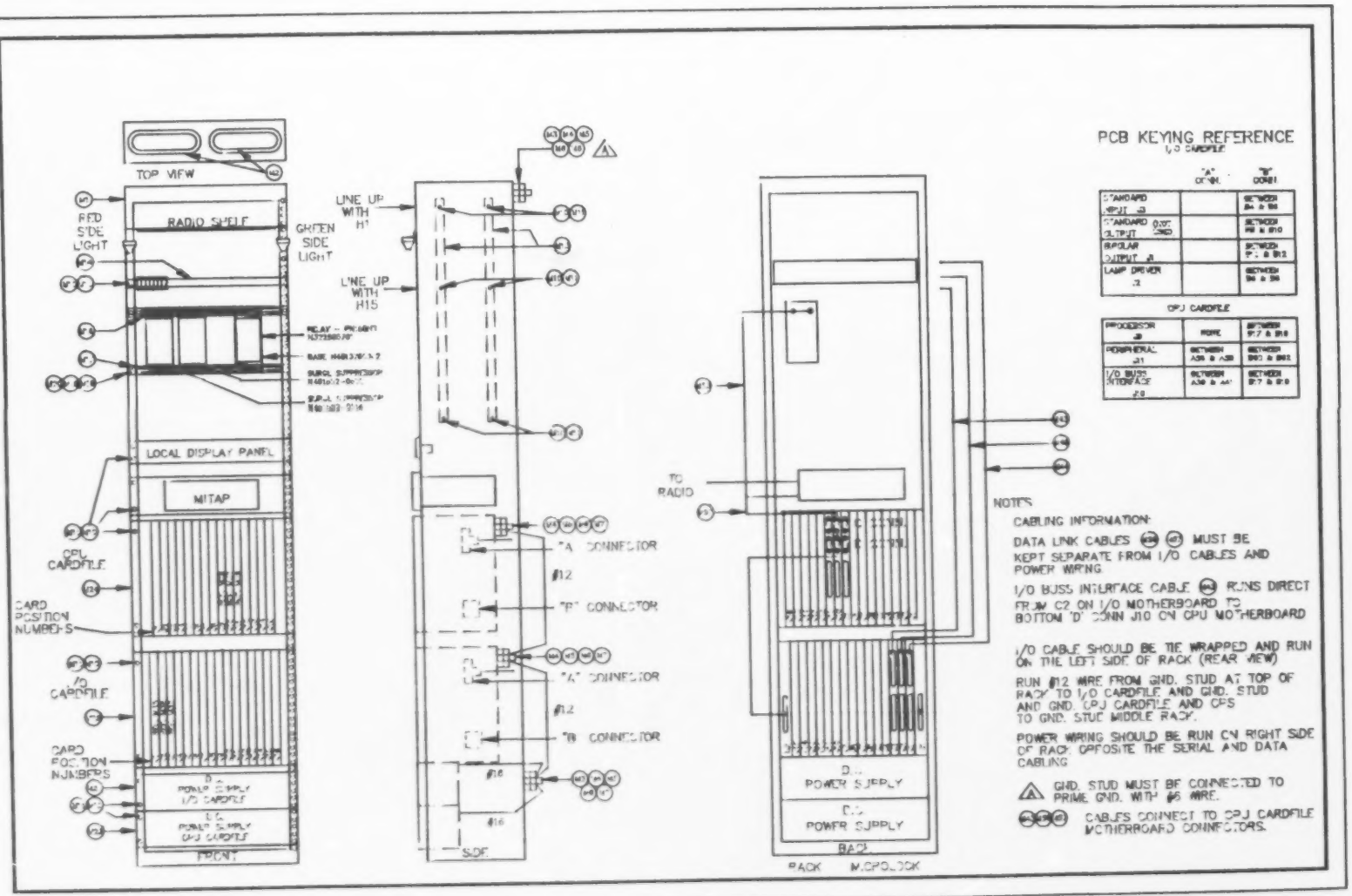
| SCALE: NONE | |
|---|---|
| G.D. | DATE |
| DES. | |
| DR. | |
| CHK. | |

CP RAIL
RADIO SWITCH CONTROL
TEST INSTALLATION
RED DEER, ALBERTA

SCC SIGNALCOM CANADA CORPORATION
6 INDELL LANE
BRAMPTON, ONTARIO

| APPROVED | DATE |
|---|---|
| SH. 2 | CONT'D ON 3 |

RSWALTB




## PCB KEYING REFERENCE

I/O CARDFILE

| | "A" CONN. | "B" CONN. |
|---|---|---|
| STANDARD INPUT J3 | | BETWEEN B4 & B6 |
| STANDARD 0.25" OUTPUT J2 | | BETWEEN B8 & B10 |
| BIPOLAR OUTPUT J1 | | BETWEEN B1 & B12 |
| LAMP DRIVER J3 | | BETWEEN B4 & B6 |

CPU CARDFILE

| | | |
|---|---|---|
| PROCESSOR J9 | NONE | BETWEEN B7 & B9 |
| PERIPHERAL J11 | BETWEEN A35 & A38 | BETWEEN B61 & B62 |
| I/O BUSS INTERFACE J10 | BETWEEN A36 & A41 | BETWEEN B7 & B9 |

NOTES

CABLING INFORMATION:

DATA LINK CABLES (W5) (W7) MUST BE KEPT SEPARATE FROM I/O CABLES AND POWER WIRING.

I/O BUSS INTERFACE CABLE (W4) RUNS DIRECT FROM C2 ON I/O MOTHERBOARD TO BOTTOM 'D' CONN J10 ON CPU MOTHERBOARD

I/O CABLE SHOULD BE TIE WRAPPED AND RUN ON THE LEFT SIDE OF RACK (REAR VIEW)

RUN #12 WIRE FROM GND. STUD AT TOP OF RACK TO I/O CARDFILE AND GND. STUD AND GND. CPU CARDFILE AND CPS TO GND. STUD MIDDLE RACK.

POWER WIRING SHOULD BE RUN ON RIGHT SIDE OF RACK OPPOSITE THE SERIAL AND DATA CABLING

⚠ GND. STUD MUST BE CONNECTED TO PRIME GND. WITH #6 WIRE.

(W4) (W5) (W7) CABLES CONNECT TO CPU CARDFILE MOTHERBOARD CONNECTORS.

| REVISIONS | |
|---|---|
| AS INSTALLED NOV 12, 1986 | |

PRIOR TO WIRING PLACED IN REGULAR SERVICE, THE OPERATION OF ANY CIRCUITS AND EQUIPMENT REPRESENTED HEREON MUST BE CHECKED BY CIRCUIT SELECTION (BREAKDOWN) AND SERVICE (OPERATION) TESTS OF THE COMPLETE SYSTEM OR SELECTION OF SUCH A SYSTEM INTO WHICH THEY ARE CONNECTED

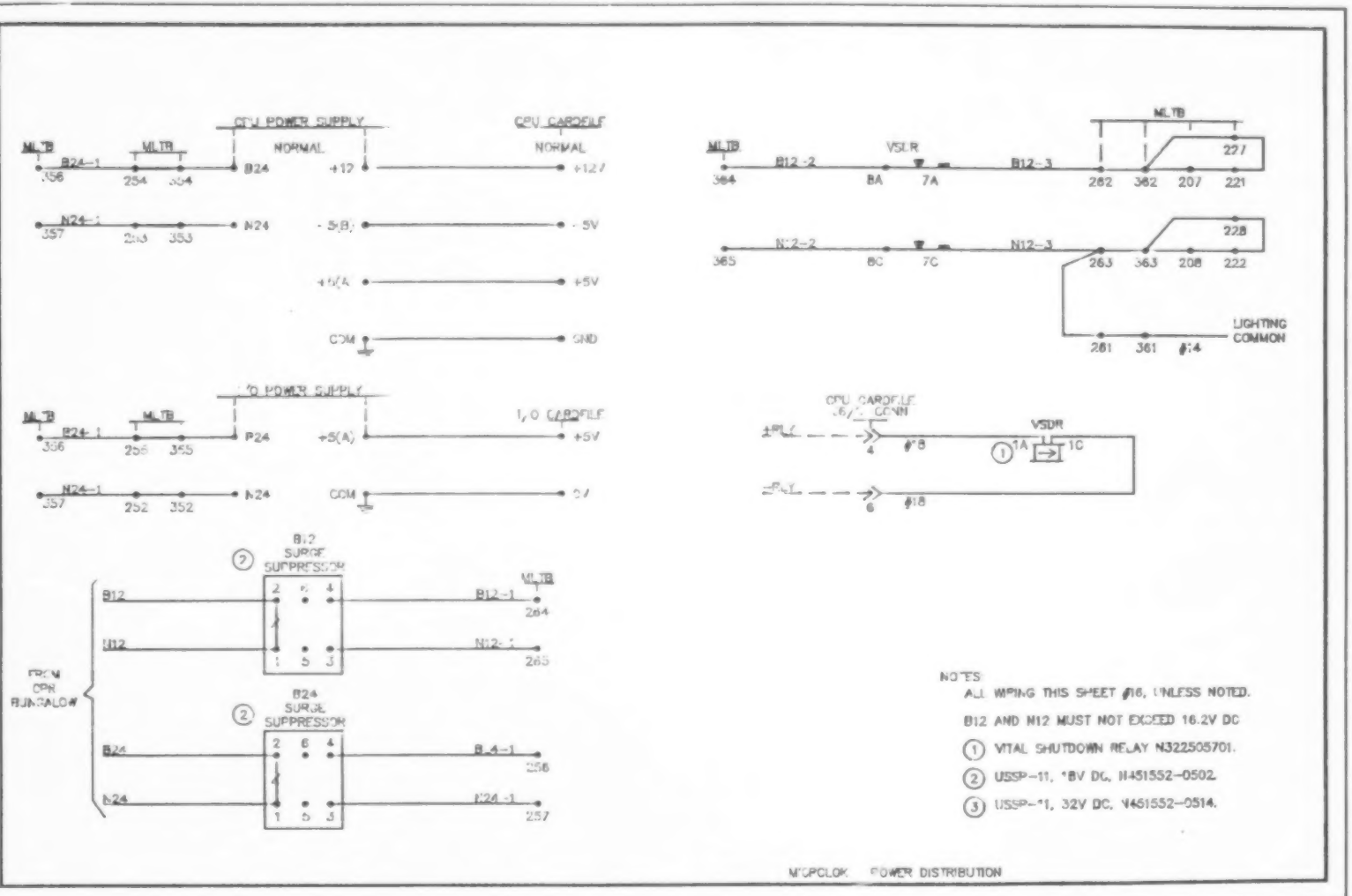
| SCALE: NONE | |
|---|---|
| D.D. | DATE |
| DES. | |
| DR. | |
| CHK. | |

CP RAIL
RADIO SWITCH CONTROL
TEST INSTALLATION
PLD DEER, ALBERTA

SCC SIGNALCOM CANADA CORPORATION
6 INDELL LANE
BRAMPTON, ONTARIO

| APPROVED | DATE |
|---|---|
| SH 1 | CONT'D ON 2 |

RSWALRCK




NOTES:

ALL WIRING THIS SHEET #16, UNLESS NOTED.

B12 AND N12 MUST NOT EXCEED 16.2V DC

(1) VITAL SHUTDOWN RELAY N322505701.

(2) USSP-11, 18V DC, N451552-0502.

(3) USSP-11, 32V DC, N451552-0514.

MICROCLOK POWER DISTRIBUTION

| REVISIONS | | |
|---|---|---|
| AS INSTALLED NOV 12, '96 | | |

PRIOR TO BEING PLACED IN REGULAR SERVICE, THE OPERATION OF ANY CIRCUITS AND EQUIPMENT APPEARING HEREIN MUST BE CHECKED IN CIRCUIT SEQUENCE (BREAKDOWN) AND SEPARATE OPERATION) TESTS OF THE COMPLETE SYSTEM OR SECTION OF SUCH A SYSTEM INTO WHICH THEY ARE CONNECTED

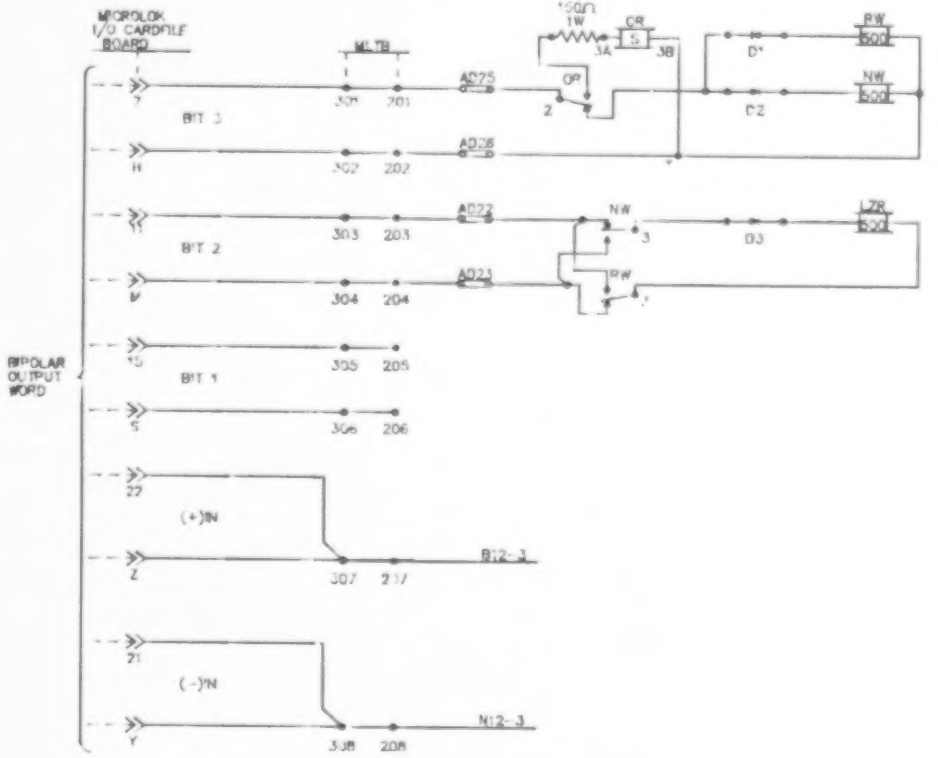
| SCALE: NONE | |
|---|---|
| D.O. | DATE |
| DES. | |
| DR. | |
| CHK. | |

CP RAIL
RADIO SWITCH CONTROL
TEST INSTALLATION
RED DEER, ALBERTA

SCC SIGNALCOM CANADA CORPORATION
6 INDELL LANE
BRAMPTON, ONTARIO

| APPROVED | DATE |
|---|---|
| SH. 3 | CONTD ON 4 |

RSWMLPD




MICROLOK BIPOLAR OUTPUTS

| REVISIONS | | |
|---|---|---|
| AS INSTALLED NOV 12 1986 | | |

PRIOR TO BEING PLACED IN REGULAR SERVICE, THE OPERATION OF ANY CIRCUITS AND EQUIPMENT PRESENTED HEREON MUST BE CHECKED BY CIRCUIT SELECTION (BREAKDOWN) AND SERVICE (OPERATION) TESTS OF THE COMPLETE SYSTEM OR SECTION OF SUCH A SYSTEM INTO WHICH THEY ARE CONNECTED

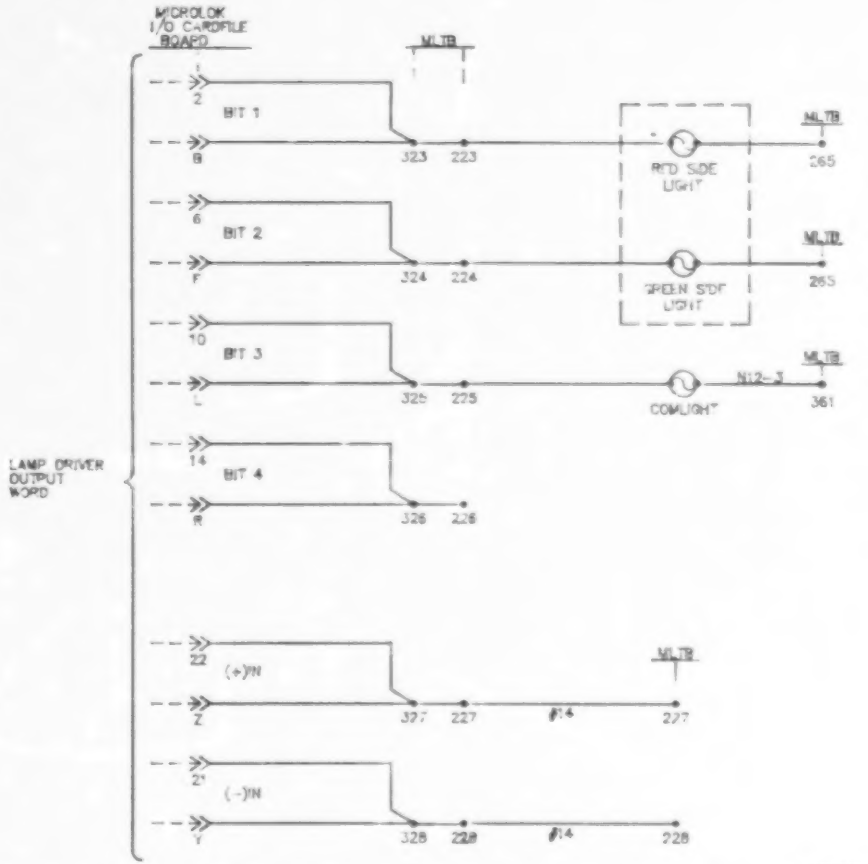
| SCALE: NONE | |
|---|---|
| G.D. | DATE |
| DFS. | |
| DR. | |
| CHK. | |

CP RAIL
RADIO SWITCH CONTROL
TEST INSTALLATION
RED DEER, ALBERTA

SCC SIGNALCON CANADA CORPORATION
6 INDELL LANE
BRAMPTON, ONTARIO

| APPROVED | DATE |
|---|---|
| SH 4 | CONT'D ON 5 |

RSWMLBPO




NOTES:

1. ALL WIRING THIS SHEET #16 UNLESS NOTED.
2. CABLE BETWEEN MICROLOK EDGE CONNECTOR PLUG AND THE PHOENIX CONNECTOR TERMINAL STRIP(MLTB) IS N45'458-6601.

MICROLOK LAMP DRIVER.

| REVISIONS | |
|---|---|
| AS INSTALLED NOV 12, 1986 | |

PRIOR TO BEING PLACED IN REGULAR SERVICE, THE OPERATION OF ANY CIRCUITS AND EQUIPMENT PRESENTED HEREIN MUST BE CHECKED BY CIRCUIT SELECTION (BREAKDOWN) AND SERVICE (OPERATION) TESTS OF THE COMPLETE SYSTEM OR SECTION OF SUCH A SYSTEM INTO WHICH THEY ARE CONNECTED

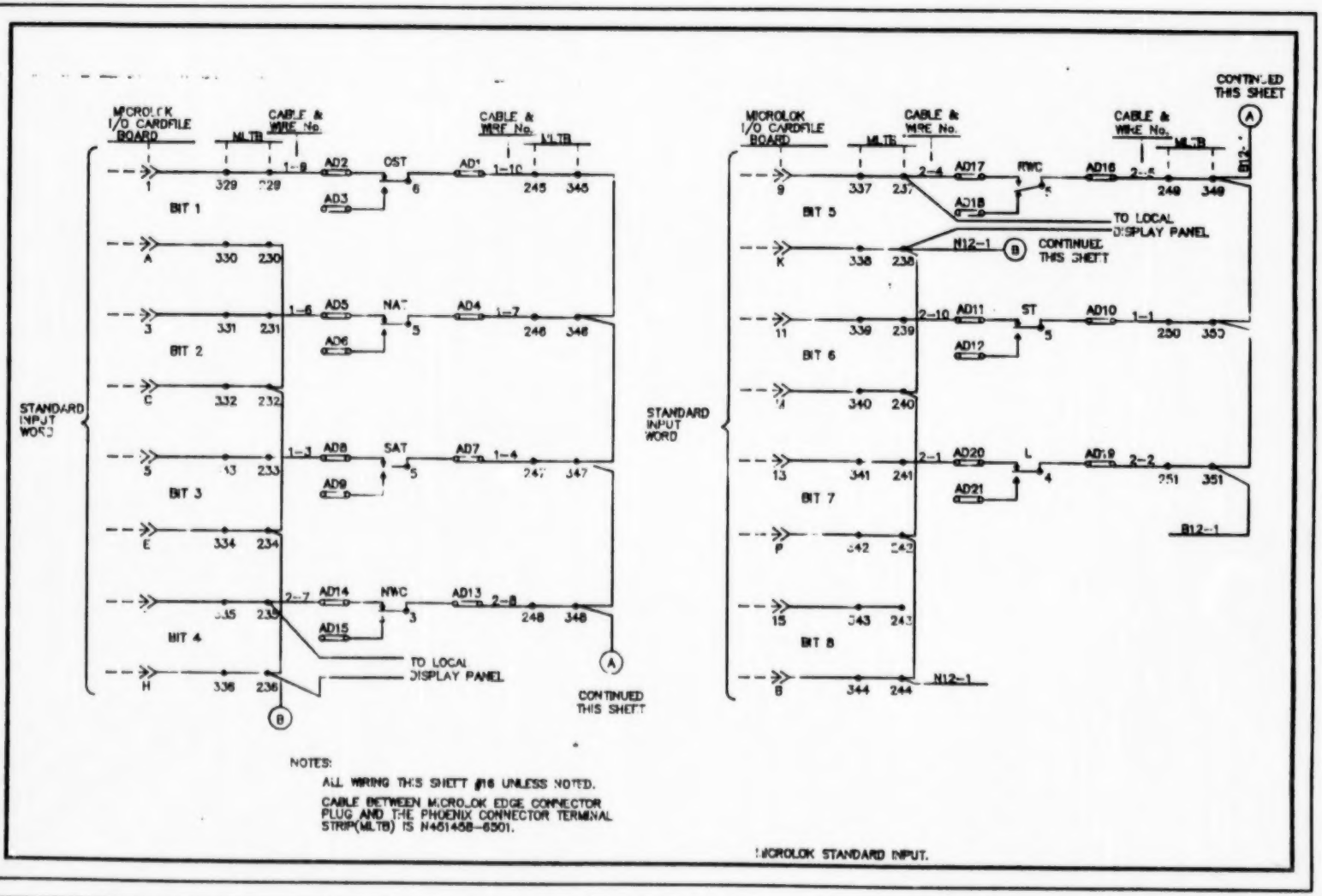
| SCALE: NONE | |
|---|---|
| D.O. | DATE |
| DES. | |
| DR. | |
| CHK. | |

CP RAIL
RADIO SWITCH CONTROL
TEST INSTALLATION
PEJ DEER, ALBERTA

SCC SIGNALCOM CANADA CORPORATION
6 INDELL LANE
BRAMPTON, ONTARIO

| APPROVED | DATE |
|---|---|
| SH 5 | CONT'D ON 6 |

RSWM.LD




| REVISIONS | |
|---|---|
| AS INSTALLED NOV 12, 1988 | |

PRIOR TO BEING PLACED IN REGULAR SERVICE, THE OPERATION OF ANY CIRCUITS AND EQUIPMENT PRESENTED HEREIN MUST BE CHECKED BY CIRCUIT SELECTION (BREAKDOWN) AND SERVICE (OPERATION) TESTS OF THE COMPLETE SYSTEM OR SECTION OF SUCH A SYSTEM INTO WHICH THEY ARE CONNECTED.

| SCALE: NONE | |
|---|---|
| G.O. | DATE |
| DES. | |
| DR. | |
| CHK. | |

CP RAIL
RADIO SWITCH CONTROL
TEST INSTALLATION
RED DEER, ALBERTA

SCC SIGNALCOM CANADA CORPORATION
6 INDELL LANE
BRAMPTON, ONTARIO

| APPROVED | DATE |
|---|---|
| SH. 6 | CONTD ON / |

RSM4.STI

| REF. NO. | APPARATUS | CONTACTS | DESCRIPTION | APPARATUS REFERENCE | MTG. BASE REFERENCE | USE | |
|---|---|---|---|---|---|---|---|
| M1 | 19" EQUIPMENT RACK | | | R396261 | | | |
| M2 | RUBBER CHANNEL | | | A075120 | | | |
| M3 | GROUND STUD | | | J507349-0124 | | | |
| M4 | GROUND NUT | | | M210285 | | | |
| M5 | GROUND NUT | | | M210286 | | | |
| M6 | STAR WASHER | | | J047672 | | | |
| M7 | NO. 12 TERMINAL | | | J730113 | | | |
| M8 | NO. 6 TERMINAL | | | J731399 | | | |
| M9 | AMP TERMINAL | | | J730196 | | | |
| M10 | SPECIAL NUT | | | J480203 | | | |
| M11 | SCREW | | | J507261 | | | |
| M12 | SCREW | | | J522018 | | | |
| M13 | ANGLE 22 7/8" | | | M392003 | | | |
| M14 | TERMINAL BLOCK | | | J794009 | | | |
| M15 | TERMINAL BLOCK | | | J794010 | | | |
| M16 | RELAY SUPPORT | | | M381333 | | | |
| M17 | RELAY SUPPORT CLIPS | | | M381298 | | | |
| M18 | BOLT | | | J46089 | | | |
| M19 | NUT | | | J48195 | | | |
| M20 | WASHER | | | J47502 | | | |
| M21 | BRACKET, WIRE SUPP. | | | N308947-001 | | | |
| M22 | PWR SUPPLY, I/O | | | N451460-2301 | | | |
| M23 | PWR SUPPLY, CPU | | | N451460-2201 | | | |
| M24 | CARDFILE, CPU | | | N451082-2901 | | | |
| M25 | CARDFILE, I/O | | | N451082-3801 | | | |
| M26 | CARDFILE, GENISYS | | | N085718-1009 | | | |
| M27 | KEYS | | | J718284 | | | |
| M28 | PCB, PROCESSOR | | | N451441-5701 | | | |
| M29 | PCB, PERIPHERAL | | | N451441-5502 | | | |
| M30 | PCB, I/O BUS INTF | | | N451441-6001 | | | |

REVISIONS

AS INSTALLED NOV 12, 1986

PRIOR TO BEING PLACED IN REGULAR SERVICE, THE OPERATION OF ANY CIRCUITS AND EQUIPMENT PRESENTED HEREON MUST BE CHECKED BY CIRCUIT SELECTION (BREAKDOWN) AND SERVICE (OPERATION) TESTS OF THE COMPLETE SYSTEM OR SECTION OF SUCH A SYSTEM INTO WHICH THEY ARE CONNECTED.

SCALE: NONE

| | |
|---|---|
| G.O. | DATE |
| DFS. | |
| DR. | |
| CHK. | |

CP RAIL
RADIO SWITCH CONTROL
TEST INSTALLATION
RED DEER, ALBERTA

SCC SIGNALCOM CANADA CORPORATION
6 INDELL LANE
BRAMPTON, ONTARIO

APPROVED DATE

SH. 7 CONT'D ON 8

REMARKS

| REF. NO. | APPARATUS | CONTACTS | DESCRIPTION | APPARATUS REFERENCE | MTG. BASE REFERENCE | USE | |
|---|---|---|---|---|---|---|---|
| M31 | PCB, CODE SYS INTF. | | | N451441-5302 | | | |
| M32 | PCB, STD INPUT (20V) | | | N451441-6402 | | | |
| M33 | PCB, STD INPUT (32V) | | | N451441-6403 | | | |
| M34 | PCB, STD RLY DRVR | | | N451441-6501 | | | |
| M35 | PCB, BIPLR RLY DRVR | | | N451441-6601 | | | |
| M36 | PCB, LAMP DRIVER | | | N451441-6703 | | | |
| M37 | PCB, POWER SUPPLY | | | N451441-3301 | | | |
| M38 | PCB, CONTROLLER | | | N451441-5602 | | | |
| M39 | PCB, OPTICAL INPUT | | | N451441-5804 | | | |
| M40 | PCB, CON DEL OUTPUT | | | N451441-4401 | | | |
| M41 | BUS BAR FOR M14,M15 | | | | | | |
| M42 | CABLE, I/O INTF 5' | | | J793098 | | | |
| M43 | CABLE, STD INPUT | | | N451458-6501 | | | |
| M44 | CABLE, BIPLR OUTPUT | | | N451458-6801 | | | |
| M45 | CABLE, STD OUTPUT | | | N451458-6701 | | | |
| M46 | CABLE, LAMP DRIVER | | | N451458-6601 | | | |
| M47 | CABLE, CONST DEL | | | N451458-3201 | | | |
| M48 | CABLE, OPT INPUT | | | N451458-3101 | | | |
| M49 | CABLE, POWER | | | N451458-3302 | | | |
| M50 | 37 WAY CONNECTOR | | | J709146-0113 | | | |
| M51 | SERIAL INTF END UNIT | | | N451667-1101 | | | |
| M52 | MICROCODE UNIT | | | | | | |
| M53 | RLY WIER #18 BLK PCV | | | A045665-0000 | | | |
| M54 | CABLE, SERIAL INTF | | RFL TO MICROLOK | | | | |
| M55 | CABLE, SERIAL INTF | | GENISYS TO MICROLOK | | | | |
| M56 | CABLE, SERIAL INTF | | MICROLOK TO MICROLOK | N451458-8502 | | | |
| M57 | CABLE, SERIAL INTF | | MICROLOK TO MICROCODE | | | | |
| M58 | CABLE, SERIAL INTF | | GENISYS TO GENISYS | | | | |
| M59 | EVENTTRAK WIRING INTERFACE BOARD | | | | | | |
| M60 | EVENTTRAK UNIT | | | | | | |

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DRAWING NO.